First Copy

June 1938

TECHNOLOGY REVIEW

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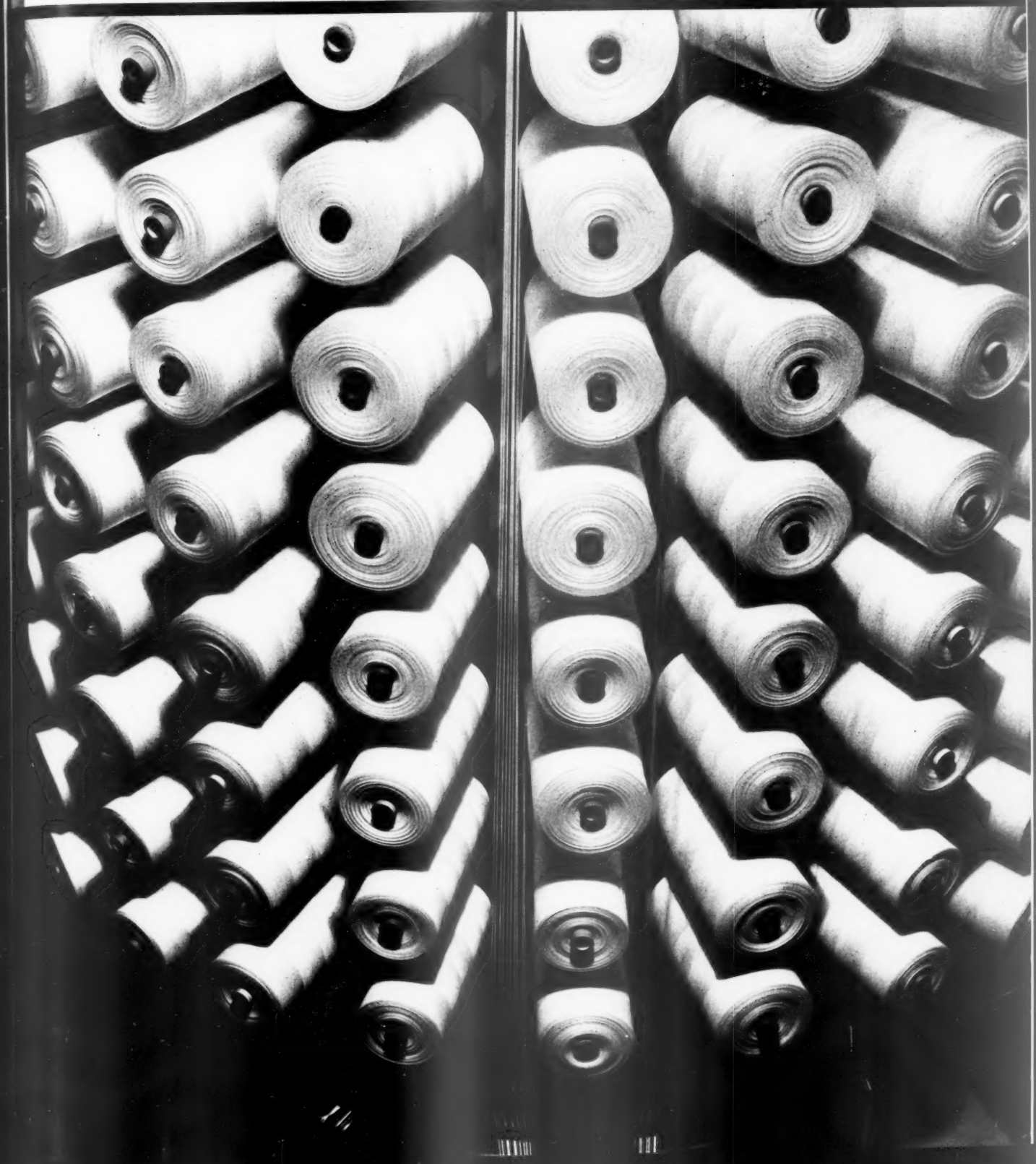

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THE TECHNOLOGY REVIEW, June, 1938. Vol. XL, No. 8. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

THE TABULAR VIEW

BECAUSE of the close partnership that has grown up in recent years between the physicist and the physician, The Review has devoted an increasing amount of space to their joint activities. An example is the article in this issue, "Exploring the Body with Atoms," by PHILIP M. MORSE (page 353), Professor of Physics at the Institute and a member of The Review staff. As President Compton pointed out in a recent address, the relation of physics to medicine can be traced historically through the interesting changes in the connotation of the word *physics*. The root meaning of physics is "that which pertains to nature or that which is in accordance with the laws of nature." The word was used originally to designate phenomena of the natural and material world as contrasted to things mental, moral, spiritual, or imaginary. It therefore referred to phenomena of living things, including the human body, as well as phenomena of the inanimate world. Later its meaning was narrowed, and in turn various branches of the natural sciences, such as biology, astronomy, chemistry, and geology, were excluded. It is interesting, however, to note that today in Webster's dictionary a physicist is defined not only as a specialist in natural sciences but as one versed in medical sciences. At least the philologists, then, still recognize the physicist's connection with the physician. Striking, too, is the fact that in France the physicist is called a *physicien*, which is almost exactly our own word for a medical practitioner. In Germany he is called *physiker*, and you may or may not know that a physicker as defined in the English dictionaries is "one who administers a physic." Despite these philological vagaries and the long separation of the physicist and physician, it is becoming increasingly clear, and Professor Morse shows it in his article, that the progress of modern science has again brought the two professions together. We see on every hand that the physicist, with his increasing knowledge and control of the forces of nature, is bringing these materials and forces more and more to the service of the physician for the curing of sickness and the preserving of health.

READERS of The Review may recall a letter published in this column last February, requesting an article explaining the mysteries of geophysics. That letter was read by a reader of The Review in Texas who wrote air mail to the Editor asking if he might provide such an article. He received an equally prompt reply asking him to proceed. The name of this alert geophysicist is ROLAND F. BEERS, '28, and his by-line appears over the article on page 356, entitled "The Great Detective Story." He is president of the Geotechnical Corporation at Dallas, Texas, and he holds a bachelor's degree from Rensselaer and a master's degree from M.I.T. Once before he appeared in The Review, writing on the same subject and under the title "Doodle-Bugs Deposed" (May, 1931). ¶In "This Ball of Clay — How Old?" published by (*Concluded on page 342*)

No. 8

Just for Fun!

A CHALLENGE

TO YOUR INGENUITY

CONSIDER the gambling device which rolls three dice simultaneously. You place your bet on any selected die number — say "2". If, in the roll, "2" turns up, you get your money back, plus one, two or three times the amount of your bet, depending on the number of times "2" appears. If "2" does not show, you lose your money.

Since there is 1 chance in 6 that "2" will turn up on any *one* die, *three* dice would appear to provide 3 chances in 6 of winning. This would leave 3 chances in 6 of losing and make the gambling odds 50/50. Actually the odds are 108/125. Can you explain?

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PRESSURE WIND TUNNEL *for* M.I.T *by* P·DM*

Above is shown one of the large corner girders for the new wind tunnel, lying horizontally on the steel welding floor. Welds in heavy steel assemblies cause distortions which are largely eliminated by clamping such assemblies rigidly to the heavily reinforced and anchored welding floor. This elliptical corner girder will be erected in a vertical position; the curved vanes which may be seen in the illustration serve to change the direction of the rapidly moving air in the tunnel through an angle of 90 degrees. This method of turning air has been found to be most efficient, producing less eddy and a more uniform air velocity of the tunnel cross-section than any other known method.

THE winds that blew at Kitty Hawk are but remotely akin to the controlled hurricanes that will dwell in the Wright Brothers Memorial Wind Tunnel.

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A P·DM welder is here seen joining a curved angular shape and a curved flat bar together to form one of the circumferential stiffeners which will give the new wind tunnel sufficient strength to resist external pressure, when the tunnel is partially exhausted to make tests of models under rarefied atmosphere. These welders are expert in directing the flow of molten metal from the electrodes, so that the finished bead has a regular and uniform appearance resembling a jeweler's pattern.

This is a section of one of the smaller elliptical girders on the welding manipulator. The purpose of this machine is to position the fillet or joint being welded so that the welding may be done at the highest practical speed. This machine rotates through about 135 degrees on the horizontal axis and 360 degrees on the normally vertical axis, which enables any part to be positioned so that the welding may be done in the down direction. Since welding may be compared to pouring molten steel into a seam, the importance of proper positioning may readily be appreciated.

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IS BASED ON
WESTERN ELECTRIC QUALITY

Alumni Day at Technology

Commemorating on June 6 the Final Departure of the Institute from the Rogers Building

THE PROGRAM

June 6, 1938

Morning

8:30 A.M.–10 A.M. REGISTRATION in the main lobby of the Rogers Building, 491 Boylston Street

8:30 A.M.–12:30 P.M. RETROSPECTIVE EXHIBITION of work in the School of Architecture, Main Exhibition Room, Rogers Building

10 A.M.–12:15 P.M. SYMPOSIUM, Huntington Hall, Rogers Building

The Impact of Science on the Arts

Speakers

WILLIAM EMERSON, *Dean of the School of Architecture*, welcoming guests to Rogers and introducing:

A. LAWRENCE KOCHER, '13, *Editor, Architectural Record*, presiding

WALDEMAR B. KAEMPFFERT, *Science Editor, New York Times*

Title: "Science and Society"

JOHN MILLS, '09, *Director of Publications, Bell Telephone Laboratories, Inc.*

Title: "Engineering and Art"

MALCOLM COWLEY, *Literary Editor, New Republic*

Title: "Technology and Letters"

FREDERICK J. KIESLER, *Director of Laboratory for Design Correlation, Columbia University*

Title: "Biotechnics and Architecture"

12:15 P.M.–12:40 P.M. FAREWELL TO ROGERS, Huntington Hall. Address by Charles-Edward A. Winslow, '98

12:40 P.M.–1 P.M. Transfer of activities to M.I.T. in Cambridge. Bus service from the Rogers Building to Cambridge will be provided

The entire program of the Symposium will be heard on an international short-wave broadcast from Station W1XAL of the World Wide Broadcasting Foundation, Boston, a non-profit organization which is supported by contributions from interested friends and listeners. This broadcast will be sent out on a wavelength of 6.04 megacycles (49.6 meters).

Afternoon

1 P.M.–2 P.M. LUNCHEON in Du Pont Court, M.I.T., Cambridge

1 P.M.–5 P.M. EXHIBITIONS in the Main Lobby and adjacent areas:

(1) The growth of an industrial design
(2) Modern mass-produced articles
(3) Streamlining in fact and fancy
(4) Selected photographs under the auspices of The Technology Review

2 P.M.–4 P.M. JOINT CLASS DAY EXERCISES with the Class of 1938 in Lowell Court. Alumni speakers: For the Class of 1888, WILLIAM G. BESLER, *Chairman of the Board, Central Railroad of New Jersey;* for the Class of 1913, LAURENCE C. HART, *General Sales Manager, Johns-Manville Sales Corporation*

4 P.M.–4:15 P.M. Adjourn to the steps of the new Architecture Building on Massachusetts Avenue

4:15 P.M.–4:35 P.M. DEDICATION of the new home of the School of Architecture

4:45 P.M. DEDICATION of the new Davis R. Dewey Memorial Library in Room 5–330

Evening

6:30 P.M.–10:30 P.M. STEIN-ON-THE-TABLE DINNER at the Hotel Statler, Boston

Speakers

MARSHALL B. DALTON, '15, *Retiring President of the Alumni Association*

KARL T. COMPTON, *President, M.I.T.*

JOHN MULHOLLAND, *Authority on Magic*

Address and demonstration on "Science and Magic"

Program for the Ladies

IT is expected that the morning symposium, the buffet luncheon, the afternoon exhibition will all be fully as attractive to the ladies as to the gentlemen.

9 A.M.–1 P.M. Room 16 in the Rogers Building will be put at the disposal of the ladies, and for those who do not care to attend the events in Rogers, the Emma Rogers Room in Cambridge will be open from 9:30 on

3:45 P.M. Open House at the home of Mrs. Karl T. Compton

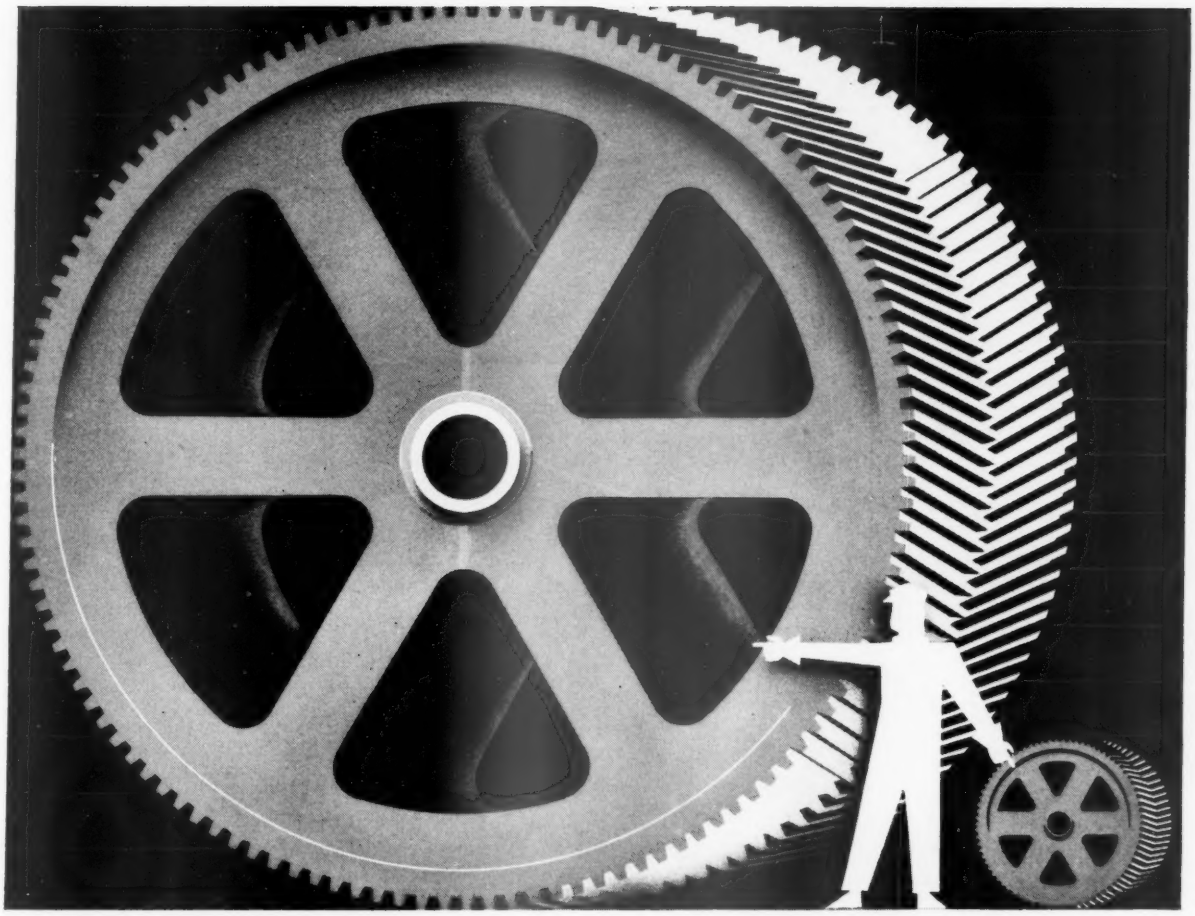
4:45 P.M. Busses leave Mrs. Compton's for a short sightseeing trip through Cambridge on the way to The Country Club, Brookline

6 P.M. Dinner, The Country Club, Brookline

7:30 P.M. Return by bus to the Statler Hotel to participate in the evening's entertainment there

Note that the morning program is in the Rogers Building, 491 Boylston Street, Boston. Go there to register. One final word: The Banquet is not to be missed. It's to be a new departure in Technology festivals and it's included in the blanket ticket costing only $5.00.

You *are invited and urged to join other Technology Alumni in this stimulating and entertaining program " . . . for it's always fair weather when good fellows get together . . ."*



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It's a big jump from a 36-inch gear to one of 16 feet weighing 53,000 pounds. Yet their case histories show that such widely varying sizes can be handled with one steel. In these instances a Manganese-Molybdenum (0.15 to 0.20% Mo) steel was used.

In the large gear simple annealing, normalizing and drawing proved sufficient to produce uniformly good physical properties. The smaller gear permitted oil quenching and drawing to even higher physical properties. And, despite the wide variations in sections, no casting defects or machining difficulties were encountered in either of the two products.

Such is the versatility of Moly cast steels. Our free book, ***"Molybdenum in Steel,"*** tells more about them; and our accumulation of practical field data is available to engineers and production executives toward the solution of any specific iron or steel problem. Climax Molybdenum Co., 500 Fifth Ave., N. Y.

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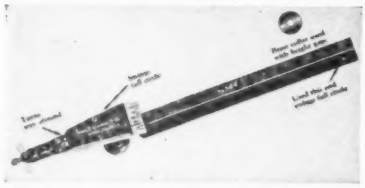

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It is sensitive, accurate, flexible, adaptable to practically every conceivable indicating operation and sells for only five dollars. Contact point which is frictionally held in rotating sleeve can contact work at any angle. Indicator can be mounted on side or top of shank or clamped to jaw of height gage. Indicator is 2½ inches long, shank 5 inches. Range, .012 by thousandths.

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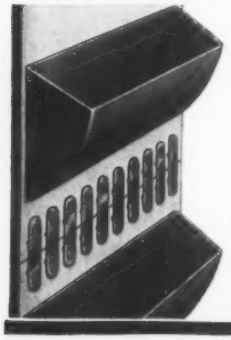

Note how recessed plates compress belt end. Internal friction and ply separation in belt ends is overcome. The tight butt of the belt ends prevents passage of materials or liquids through the belt. Made in steel, "Monel Metal," non-magnetic and abrasion resisting alloys. Five sizes. Sold by jobbers and belting houses. Consultation regarding belt joining invited.

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THE TABULAR VIEW

(*Concluded from page 337*)

The Review last April, Professor Morse described how the "pure" geophysicist is exploring the interior of the earth. Mr. Beers's article is a sequel that describes the work of the "applied" geophysicist in the workaday world of oil exploration. ¶ Each year a score or more of M.I.T. juniors and seniors compete for the Stratton Prizes, monetary awards given for excellence in the oral presentation of scientific papers, and this year the Editor, much to his surprise, derived a great deal of pleasure from judging the semifinals of this contest and he also pounced upon one of the papers as a pertinent article for The Review. This is the article, "Should I Trade in My Car?" by VERNON G. LIPPITT, '38 (page 372). Mr. Lippitt, as an outstanding senior, this year received a Rogers scholarship and he now has the added distinction of being, with possibly one exception, the first undergraduate to have a formal article appear in this stately and learned family journal. Mr. Lippitt, we might add, placed third out of six in the final judging for the Stratton Prizes.

FROM a reader of The Review who shall go unnamed, we have received the following letter: "After several weeks of cautious investigating in a field to which I had never before given the least attention, I recently decided to purchase a $225 phonograph-radio, with record changer and all the trimmings, for the purpose of enjoying classical piano music at home. Just as I was ready to write the check and turn in the order . . . I happened to read the editorial comment in the April number of The Review, page 258, to the effect that after five playings the first flower of the tone quality is gone from these recordings, after 25 the needle hiss increases in prominence, and after 100 the records are completely washed up. This had the effect of sending me into a state of complete estivation, as far as that purchase was concerned. I should be interested to learn, if you care to state, whether the several manufacturers of phonographs have contested your editorial statement; also whether the new needle suspension developed at the Cruft Laboratory and mentioned in the same editorial statement is to be made available to the public within a reasonable period." ¶ We are chagrined that the article in The Review halted this gentleman in his plan to equip his home to play records. We have recently done it ourselves, despite the needle hiss and despite the obvious wearing of the records. These we are willing to bear because we want music when we want it, but at the same time we anxiously await better phonographic equipment — equipment that is kind to tender records and that is not designed mainly for people with tin ears. ¶ The statements in The Review's article were correct so far as we have been able to determine and have not been challenged. Those who wish more information about the pickup developed at the Cruft Laboratory are referred to Professor F. V. Hunt of Harvard University, who will gladly supply further information.

Electricity's eyes never close . . . its service is never asleep

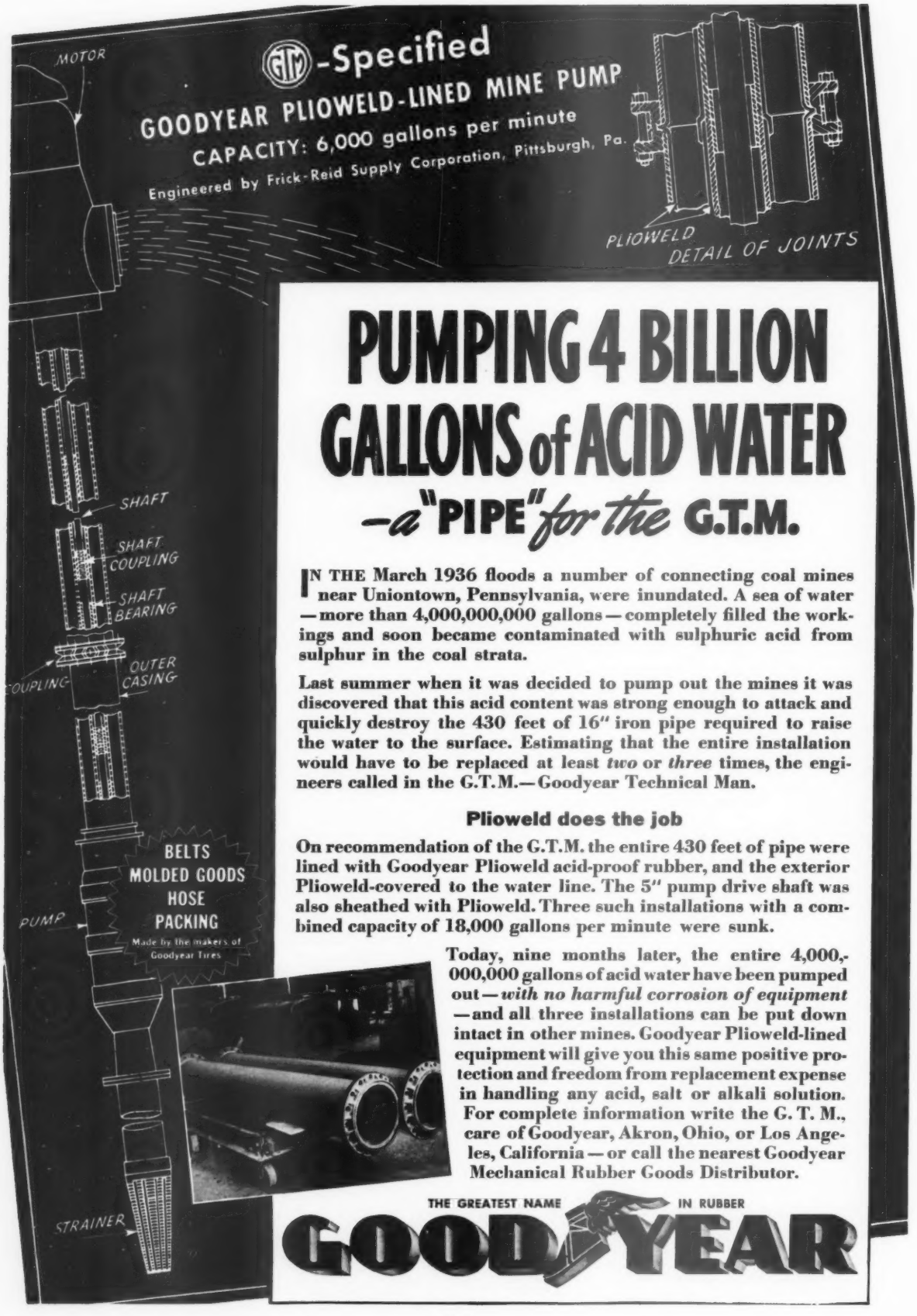
A BABY'S cry in the night . . . a midnight prowler . . . sickness that strikes in the dark. How grateful we may well be in emergencies for the never-failing service of electric light! Yet how few of us realize what it takes to make that service possible — what it has cost over the past 50 years in the way of investment, invention, engineering, and human toil.

Trace the wires from your light switches, and you will find them connected to an intricate system of transformers, protective devices, transmission lines, substations and generating plants that cost millions to build. To keep such systems functioning day and night, through heat and cold, storm and flood, costs millions more. Vast additional sums go yearly into research, development, and improvement. Electric service can never be called "perfect," because it is always being made better and cheaper!

Westinghouse contributions to this progress have helped to blaze the trail of electricity from its source to its infinite uses. The generating systems — the transformers and networks — the lamps that burn longer and brighter at less cost — all owe something to Westinghouse co-operation with progressive power companies. This partnership in the public interest is of direct benefit to every industry, business office, farm and home in America.

Westinghouse

The name that means everything in electricity



PUMPING 4 BILLION GALLONS of ACID WATER

—a "PIPE" for the G.T.M.

IN THE March 1936 floods a number of connecting coal mines near Uniontown, Pennsylvania, were inundated. A sea of water — more than 4,000,000,000 gallons — completely filled the workings and soon became contaminated with sulphuric acid from sulphur in the coal strata.

Last summer when it was decided to pump out the mines it was discovered that this acid content was strong enough to attack and quickly destroy the 430 feet of 16" iron pipe required to raise the water to the surface. Estimating that the entire installation would have to be replaced at least *two* or *three* times, the engineers called in the G.T.M.—Goodyear Technical Man.

Plioweld does the job

On recommendation of the G.T.M. the entire 430 feet of pipe were lined with Goodyear Plioweld acid-proof rubber, and the exterior Plioweld-covered to the water line. The 5" pump drive shaft was also sheathed with Plioweld. Three such installations with a combined capacity of 18,000 gallons per minute were sunk.

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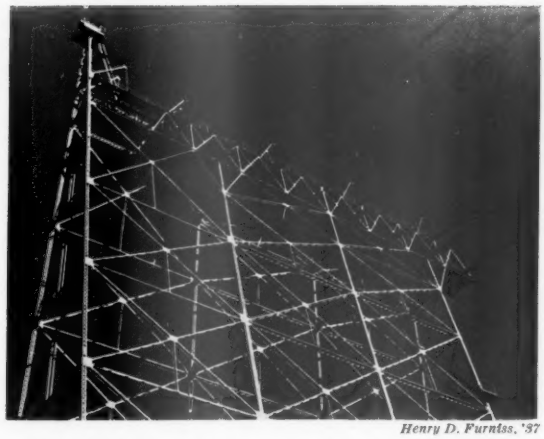
GOODYEAR



Henry D. Furniss, '37

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VOL. 40, NO. 8 JUNE, 1938

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James N. Doolittle — Courtesy of Fortune

THIS BEHEMOTH OF THE RAILS SHOWS HER METTLE EVEN IN UNDRESS

THE
TECHNOLOGY REVIEW

Vol. 40, No. 8 June, 1938

The Trend of Affairs

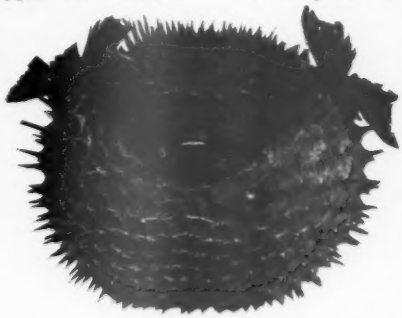
Double-Duty Wires

BEFORE the World War the discovery was made that radio waves, chiefly remarkable for their ability to fly through space, can with equal ease skim along wires. As a consequence a single pair of wires can carry, simultaneously, a number of separate messages. By providing a separate radio transmitter and receiver for each message and by employing the principle of tuning, as many as 20 or 30 messages can be imposed together on a single telephone circuit. At the receiving end, each receiver selects the message to which it is tuned, exactly as does an ordinary radio set.

The principle of making wires serve double duty is not confined to communications practice. Power companies for years have found possible the use of high-tension transmission lines not only for carrying power but for carrying telephone conversations and relay-control impulses as well. The utilities have applied this practice not only to the control of their own transmission systems but also of their customers' appliances. In some parts of the country where it is common practice to use electricity for hot-water heating, the consumer's heater is turned on and off from the power house by carrier impulses sent over the power lines to actuate a local relay in the heater assembly. In this manner the peak load of the system is partially under the control of the dispatcher, and the cost of the service can be proportionately reduced.

Now comes word that carrier methods can be applied in a variety of ways within the home. Time was when the electric wiring in a house served but one purpose — to conduct power from the street circuit to lamps and appliances. But by applying the principle of carrier communication, the house owner may utilize his house wiring in ways removed from the prosaic one of carrying power. One important example is interroom communication, by which busy parents, for example, may keep tabs on the nursery. The equipment consists of two carrier-communication units, a transmitter containing a microphone and a receiver containing a loud-speaker. The microphone unit is plugged to any convenient wall socket in the nursery, while the loud-speaker unit is attached similarly in the living room, kitchen, or any other room in the house. Thereupon, any sound in the nursery is transmitted by the microphone unit, over the power lines, to the loud-speaker unit. The power lines are in no way affected by this extra duty. In some instances talk between houses is possible or between different apartments in the same building. If this is not desired, the communication may be confined by inserting small choke coils in the fuse box.

Next year's more expensive radio sets may employ carrier methods for the remote control of tuning and volume. A small tuning unit, possessing station and volume-control push buttons, is plugged in at any outlet in the house. The unit generates a radio-frequency carrier, on which the control impulses are imposed. The carrier travels over the light wires to the receiver, where it initiates the action of a small neon-filled tube. This tube, which consumes no power when the set is not in use, operates a relay through which power is applied to the receiver. Thereafter the control impulses,



Black Star

PORTRAIT

. . . of the handsome sea hedgehog after he has inflated himself with air

sent over the lighting circuit by the tuning unit, are applied directly to the tuning and volume mechanisms of the set. Still another impulse turns off the radio and sets it in readiness to be turned on again at any later time.

When the system was first disclosed to members of the Institute of Radio Engineers, one member rose to say that he welcomed its advent, provided the system could be extended so that he could turn off his neighbor's set by remote control. Just such possibilities have concerned the engineers now at work on the problem, but by the latest advices they feel confident that the new receivers will preserve their individuality.

Tough Bubbles

BUBBLES are a conventional symbol of all that is transitory and fleeting, and froth of all that is without substance and consequence. "Life," wrote Chang Po-tuan in the first poem of his versified "Essay on the Understanding of the Truth," "lasts but a moment if we look at it on a larger scale of time. Life is like a bubble which is floating on the surface of water." Chang Po-tuan's essay, written in the 11th Century, is devoted to alchemy, to the art of prolonging life and procuring longevity and immortality by the use of chemically prepared medicaments. It would surely interest the ancient sage and perhaps amuse him if he could know that modern science, while still working on the age-old problem by means of hormones, vitamins, and chemotherapy and by an attack upon the chemical causes of disease and senescence (see page 350), is also interested in the longevity of soap bubbles — for these are useful tools in the researches of the engineer.

James N. Doolittle

The behavior of soap films under pressure is entirely analogous to that of beams under stress, and such films used in research on machinery and structural design provide an experimental check upon the stress distribution in beams which may be calculated mathematically. They also provide a means of determining the torsional rigidity and the stress of irregular sections which are not amenable to mathematical calculation. Soap films which will last in the air of the laboratory for 20 minutes or more are sufficiently long-lived for these experiments. They are not difficult to make but are short-lived in comparison with the films and bubbles which Sir James Dewar, Boys, Lawrence, Prandtl, Green, and other investigators in this country and in Europe have made in numerous studies on the nature of soap films and on the factors which influence their longevity.

The enemies of soap bubbles are evaporation, dust, oil droplets, and carbon dioxide. Dewar blew his bubbles in glass-walled boxes, closed to prevent evaporation of moisture and filled with dust-free air procured from liquid air and purified by passage through soda lime and through cotton wool dampened with glycerin. His most notable bubble was one which was 20 centimeters in diameter and lasted for 95 days. Flat films in bottles lasted much longer. Dewar used a five per cent solution of pure potassium oleate in a 50:50 mixture of glycerin and water.

Lawrence found that sodium oleate worked as well as the potassium salt and that ammonium and triethylamine oleates were even better. All investigators have agreed that the oleates are better than stearates, and of ordinary soaps the best is authentic Castile, which is made from pure olive oil. The function of the glycerin is believed to be the stabilization of the films against local discontinuities which may arise from various causes. Lawrence procured films as large as 19 centimeters in diameter which lasted in closed vessels for three years, and bubbles 40 centimeters in diameter which endured for 100 days. No such longevity as this can, of course, be expected of films in the open air, which are free to evaporate and are subject to damage and rupture by particles of dust.

G. A. Cook in the April number of the *Journal of Chemical Education* reports experiments on the preparation of soap bubbles for use in chemical lecture experiments, such, for example, as that in which a bubble is filled with hydrogen and floats upward, demonstrating the lightness of hydrogen, or that in which a bubble is filled with a mixture of hydrogen and oxygen and is exploded in mid-air. Such bubbles must withstand the fumes and dust of the lecture room and they ought to last long enough for all of the class to see them. Cook secured his best results with a three per cent solution of triethanolamine oleate in water to which 3/10ths of its volume of glycerin had been added — bubbles which lasted for more than 17 minutes and films which lasted for more than three hours. This is indeed long life in the air of the laboratory and the storm and stress of the classroom, and is not to be compared with the longer, more placid life of the bubbles of Dewar and of Lawrence, which lived out their sequestered, monastic existence in the purified dead air of closed glass boxes.

Even makers of bubble blowers for children now supply soap which yields more enduring bubbles than household soap. Bubble technology marches on.

Woolworthian Luxury

MUCH of Bulgaria's income is derived from growing flowers from which the essential oils are extracted to be blended later into perfumes. The essential oils were once almost precious substances and are still expensive because flowers and fruits usually contain them only in minute quantities, making extraction a difficult, tedious process. A ton of geranium leaves, for instance, will produce less than two pounds of geranium oil; a ton of rose petals — 3,000,000 flowers — will yield only about one-half a pound of attar of roses. Rose oil, therefore, is worth from $125 to $175 a pound; but in spite of the rapidly growing use of perfumes for personal and manufacturing applications, the Bulgarian government has issued, over the past few years, a whole series of edicts designed to decrease the acreage devoted to growing roses, to eliminate entirely the growing of white roses — which give only half as much oil as the red variety — and to encourage the raising of chrysanthemums for the extraction of insecticides. The authorities at Sofia believe that the former market for their rose oil will never be fully regained; they are probably right. Natural attar of roses costs more than $125 a pound, as previously mentioned; its synthetic twin costs $22.50 a pound.

Bulgaria's loss, however, is the world's gain, for the synthesis of innumerable aromatic compounds has permitted the masses not only to smell as only the rich once could (a step toward democracy?) but has also permitted them to anoint themselves with scents never before known to man or beast. Symbolic of the triumph of the fractionating column over the flower petal is the price of violet oil. Once a 10 per cent concentration of uncertain quality cost $400 a pound; its synthetic counterpart in a 100 per cent concentration is worth about $4.00 a pound. Inferior in quality, tremendously higher in price, the natural essence has suffered the fate of most products thus outmatched — total eclipse. For some flower odors, such as lilac and lily of the valley, no price comparison is possible, for the natural essences were never successfully extracted. But the greatest contribution of the chemist toward good and cheap perfume is probably the synthesis of certain large-ring carbon compounds which have the characteristics of musk and civet essences, the glandular secretions whose fixative and blending powers make possible superior perfumes. Were pure musk essence ever to reach the market — which it never has — it would be worth, probably, about $40,000 a pound. Sixteen carbon atoms can be joined by Du Pont chemists into a molecule which does everything that natural musk does but costs about $250 a pound. Nevertheless, in spite of radical alteration of price and volume factors, more essential oils still come from natural than from synthetic sources.

So far, the most apparent result of all these oxidations, esterifications, condensations, evaporations, crystallizations, and much smelling in between, has been the yearly exchange by American women of $200,000,000 for many more million pretty containers. About 90 per cent of the perfume disposed of in this country, accounting for some 15 per cent of the value of such substances, is sold in five-and-ten-cent stores. Of the average ten-cent cosmetic sale, two cents goes for profit; six cents goes for the container; and the remaining two cents covers the manufacturing cost.

One conclusion to be drawn is that American women are a very sensible lot, for there are few similar sums spent in this country which bring a greater return in satisfaction and confidence. They may not be able to quote Dr. M. T. Bogart, who states that "as an analytical instrument, the nose is far more delicate than the spectroscope," or Kipling, who said, more to the point, that "smells are surer than sights or sounds to make the heart strings crack." But they know that scents can carry tremendous emotional stimulus, the more potently because they generally work subconsciously. Western menfolk have always vehemently denied any weakness toward mere smells, but shrewder individuals have for long realized that, properly utilized, aromas could be made into highly effective sales tools. As soon as the Crusaders reintroduced a few civilized touches into Europe, among them perfumes, the master glovemakers of France began to use them on their products and thus became the first in a notable line of perfumers. Today mostly women's gloves are perfumed. Perfumes were being used in soaps quite widely by the time of the Second Empire in France, but aromas came from relatively cheap products — lemon oil, lavender, sandalwood, and honey. Even such soaps were far beyond the reach of the masses. The synthetics, however, have given the soap manufacturer a wide range of odors which will not produce discoloration, will not boil off under the high temperatures of manufacture, and are cheap enough to be included even in laundry soaps.

A huge outlet for sweet smells is the cigarette industry. Although frankly perfumed cigarettes have only a small market, every widely used cigarette is flavored, that is, contains some spice, extract, essential oil, or

James N. Doolittle

HOLLYWOOD CURVES

Water-supply dam for the Cinema City

sugar that will modify the taste and odor of the tobacco. In 1929, for instance, a favorite was coumarin; one manufacturer found that maple sugar gave somewhat the same smell and used 4,000,000 pounds of it in a year.

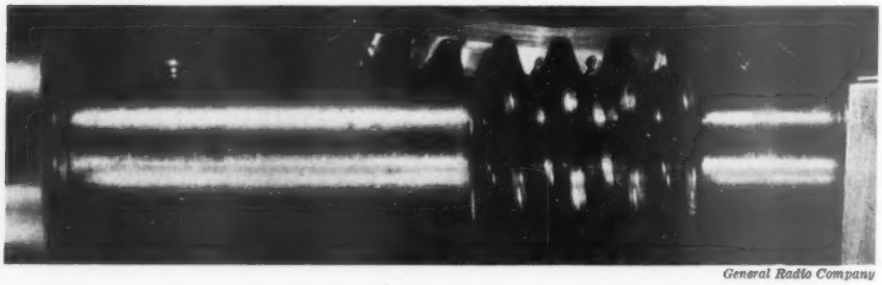
A breath of luxury is now being given to articles far less intimate than cigarettes. Many fly sprays, for instance, now contain up to six per cent of perfume, and, where means allow, appropriate variations on the idea may be made. One millionaire gave a barn dance at the height of the New Jersey mosquito season, but decided to have the party exclusive without the need for gas masks. A chemist was called in, a scent of new-mown hay added to the spray, and the mosquitoes died a sweet death. The textile industry, however, offers a more imposing opportunity to the perfumer — if that is the correct term. Many processes and dyes used in the finishing of fabrics leave residual odors. As an example, silk is sometimes immersed in a vegetable-oil bath which leaves small traces behind that later turn rancid. But one manufacturer who developed a deodorizing substance a few years ago found no takers among finishers or dyers because they were not receiving any complaints. The stores, however, were more acutely aware of consumer preferences, and an appeal to them was successful in developing a demand for the product. More recently, dyers of crush-resistant velvets have turned to perfumes to mask undesirable dye odors.

The Diseases of Civilized Man

BETTER adjustment of man's body to the demands of an increasingly complex environment is a problem made more difficult by the lag between the rate at which environment changes and the infinitely slower rate of natural accommodation. The position of cardiovascular diseases as most potent cause of death among modern civilized men illustrates the case clearly, if one recognize that the stress and strain consequent upon the constant high nervous tension of modern civilization contribute directly to the production of these ailments. The greater prevalence of heart disease, hardening of the arteries, peptic ulcer, and other digestive disorders among professional men has led in the past to the theory that some such connection existed between the "diseases of civilized man" and the demands which his environment and activities put upon his nervous system.

The first definite experimental support for the theory is contained in experiments described recently at the annual meeting of the American College of Physicians by Professor George Edward Hall of the department of medical research, University of Toronto. The culpable agent in question is the chemical acetylcholine, which acts as a vehicle or catalyst in the transmission of nerve impulses, being secreted by the parasympathetic nervous system, one of the two divisions of the autonomic nervous system which controls the so-called involuntary activities of the body, such as breathing. The second division, the sympathetic system, liberates, in postganglionic nerve fibers, a second powerful drug, adrenin, which resembles the heart stimulant, adrenalin, produced by the adrenal glands. A delicate balance between the two chemicals is maintained in a normally functioning nervous system, according to Professor Hall's evidence.

Upsetting this balance by means of daily doses of acetylcholine to experimental animals, Professor Hall found that diseases of the heart and stomach closely resembling the diseases of civilized man occurred in the subjects. If the delicate adjustment of the human nervous system can be similarly upset, not by deliberate dosage with acetylcholine but by excessive secretion of it because of the strain of civilized life, a theory is suggested for the origin of the degenerative diseases. There is possibility of a means of treatment for these ills, for already Professor Hall's experiments have shown that



General Radio Company

Westinghouse Electric and Manufacturing Company

HYACINTHS DREDGE

This odd-looking craft scoops up the dense growths of water hyacinths that infest the bayous of the lower Mississippi, impeding navigation

the drug atropine inhibits the action of overdoses of acetylcholine in test animals.

The reverse of the acetylcholine medal appears in a recent communication to *Science* describing the use of guanidine hydrochloride, a synthetic preparation, in cases of myasthenia gravis — an excessive fatiguability of the muscles which leads eventually to paralysis. A. S. Minot, Katharine Dodd, and Samuel S. Riven of the Vanderbilt University Hospital report that decreased sensitivity to the action of acetylcholine is probable in myasthenic muscles. Guanidine temporarily restores a more normal sensitivity, permitting the muscles to function better in response to nerve impulses.

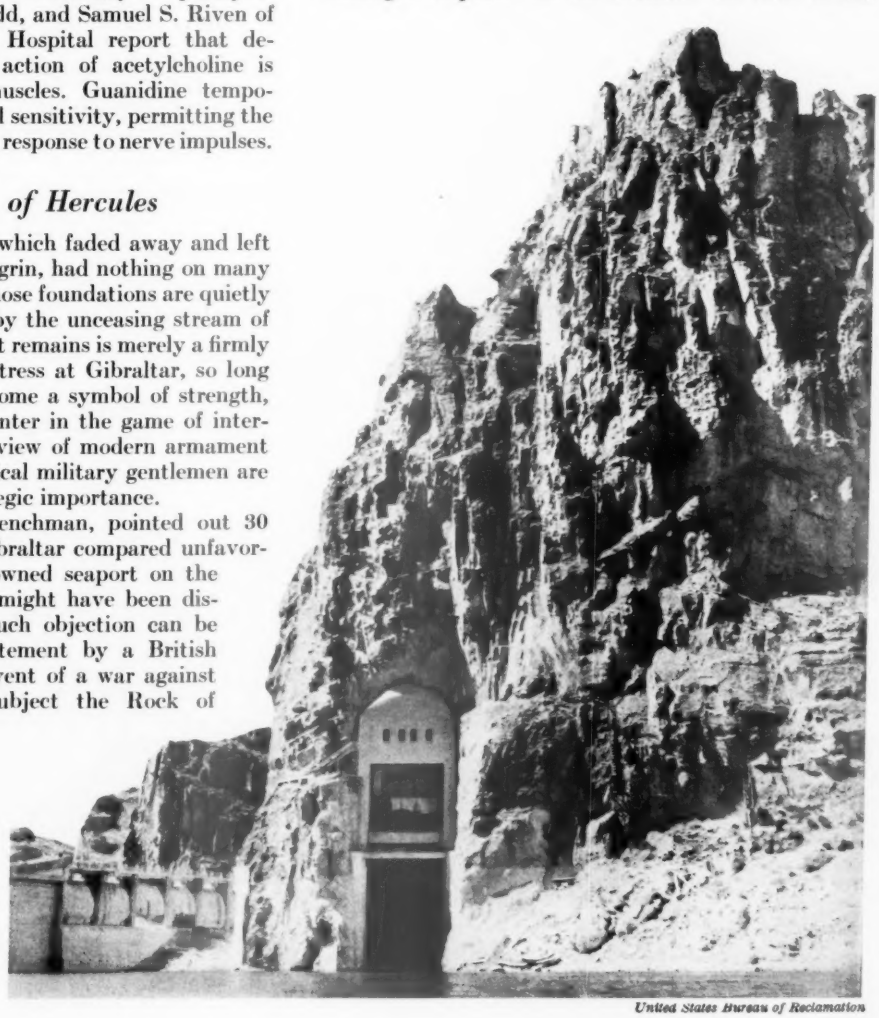
The Tottering Pillars of Hercules

CARROLL'S cat, the one which faded away and left Alice staring at only a grin, had nothing on many a firmly established truth whose foundations are quietly and unsuspectingly eroded by the unceasing stream of technical advance, until what remains is merely a firmly established illusion. The fortress at Gibraltar, so long impregnable that it has become a symbol of strength, may still be a powerful counter in the game of international diplomacy, but in view of modern armament developments, certain skeptical military gentlemen are already questioning its strategic importance.

When René Pinon, a Frenchman, pointed out 30 years ago that as a base Gibraltar compared unfavorably with Bizerte, French-owned seaport on the African Coast, the analysis might have been dismissed as prejudiced. No such objection can be raised against a recent statement by a British vice-admiral that "in the event of a war against Spain, siege guns could subject the Rock of Gibraltar to a continuous bombardment and airplanes could bombard it from Algeria and Morocco. The rock is untenable in a war against Spain [contrast this bald statement with recent utterances by the British Foreign Office that an insurgent victory in Spain would not necessarily be against the best interests of Great Britain] and would be exceedingly unpleasant to live on in the event of a war with France." He suggests that, as soon as Spain settles down again, Great Britain offer to exchange Gibraltar for Ceuta, on the opposite shore.

As background to the admiral's words, it might be remembered that the last siege to which the famous fortress was subjected occurred in 1779 to 1783 and that drinking water is obtained mainly from rainfall, although storage tanks can hold some 6,000,000 gallons in reserve.

More recently, Lieutenant Commander Charles Moran, United States Naval Reserve, has pointed out that because of the increased radius of action of modern fighting ships, "positions 'commanding' the straits are as numerous as the 'keys' to the Caribbean or the 'strategic outposts' on the Pacific." In view of the



United States Bureau of Reclamation

THE SPECTACULAR

. . . setting of the Horse Mesa Spillway, Salt River Project, Arizona

IN DRY DOCK

The screw of the Alabaman *of the American-Hawaiian Steamship Company*

tremendous amounts of complicated equipment and elaborately processed materials required by modern sea and air fleets, a good base should be backed by a large area which is friendly, thus protecting its rear, and should be heavily industrialized, thus enabling the base to support the fleet instead of the reverse. Gibraltar apparently lacks these assets.

Among points which Moran feels could be made into bases rivaling Gibraltar in effectiveness are Tarifa — an old Moorish town whose onetime success in dominating the straits is attested to by the word "tariff" — Cádiz, Oran, and Melilla. "The Pillars of Hercules," he exclaims, "are becoming a colonnade!"

Strange—Hidden

FORTY years ago their discovery was noted in the scientific world; ten years ago they were still too rare to be laboratory curiosities; in ten months, perhaps, they may be sold, like the perfumes described on page 349, over the counters of five-and-ten-cent stores. This is just another example of what happens when engineers give the public what it wants, even if the public has to be told what it's asking for.

With the ardent unanimity that politicians dream about but never witness, householders desire to reduce their electric bills, the important factor in which is current consumed by incandescent lamps. The cost of operating these lamps, large as it now is, would be far greater had Langmuir not conceived the gaseous atmosphere 25 years ago. This cost may soon become substantially smaller because a number of French scientists and technicians have succeeded in isolating in commercial quantities the gases which best meet the conditions for such an atmosphere: no chemical action on the filament; minimum heat conductivity; high resistance to the diffusion of tungsten vapor. Argon and nitrogen are good; krypton and xenon are much better. The term krypton, however, means hidden; xenon, strange — designations well deserved in light of Lepape's determinations that the air contains one part in 1,000,000 of krypton and one part in 20,000,000 of xenon, these ratios, by the way, being respectively 20 times and 15 times larger than had been supposed.

Lepape also discovered that these gases were naturally concentrated in the liquid oxygen baths used in the machines that separate oxygen and nitrogen from air and, by 1923, had worked out a method of extraction that enabled him to produce enough of the gases, mixed in the proportions in which they exist in air, for the preparation of laboratory test lamps. Five years later Georges Claude (known for his invention of the neon sign, for his work on the commercial liquefaction of gases, and for his economically futile attempt to generate power from the temperature difference existing between the top and bottom layers of the tropical seas) evolved a process for the continuous production of several dozen liters of the two gases daily. Development work by L'Air Liquide Société has continued, and today at least two plants whose principal products are these rare noble gases are operating in Europe.

Krypton-xenon filled lamps are already being sold in France. Compared with the argon-filled type which converts 10 per cent of the energy entering it into visible light, the new lamps can produce 13 per cent of "seeable" rays. Considering a 1,000 lumen unit (about 64 watts), their operating cost is about 16 per cent less than that of a standard gas-filled lamp, but their cost is considerably higher. A 64-watt krypton-xenon lamp sells for 13.65 francs, 5.90 francs more than a 60-watt argon lamp, which, however, yields only 75 per cent as much light.

Garrison

WILLIAMSBURG (VA.) INN

Awarded first prize at the annual exhibition of the Boston Society of Architects and the Silver Medal as a "work of major importance" at the 1938 exhibition of the Architectural League of New York. Designed by Perry ['07], Shaw and Hepburn ['03], who supervised the reconstruction of Williamsburg

Exploring the Body with Atoms

Examining Living Organisms without Taking Them Apart

By Philip M. Morse

The Physicist Goes to the Aid of the Physician — The Monkey-Wrench Effect — How the Discovery of Radioactive Isotopes Makes It Possible To Follow Life's Chemistry, Atom by Atom

IT seems a far cry from the study of neutrons, electron multipliers, and superhigh-voltage generators to the study of living organisms; nevertheless it seems probable now that some of the most exciting and important applications of recent advances in physics will be in biology. In this latter field the physical methods will be used as tools, and the results will be obtained by biologists and medical men, working in close coöperation with the physicists. Coöperation among experts in separated fields seems to be a growing fashion these days, one of the most promising aspects of modern science.

The study of the mechanism of life has its own peculiar difficulties and hindrances, many of which are present only in a minor degree in the study of nonliving matter. Some of these difficulties spring from the facts that the important property of living matter is its coöperative organization and that most attempts to study the organism destroy the organization, leaving the student with dead parts on his hands. One would have difficulty in understanding the mechanism of a watch if its parts cascaded into one's lap every time the case was opened.

Physics has had a somewhat similar problem in the study of the atom. The research worker's fingers always seem to be monkey wrenches when he probes the atom; and the effect of such crude tools on delicate machinery is proverbial. After many attempts to get rid of the monkey wrenches and still make the measurements, the physicist has become reconciled to the presence of the monkey wrenches and he approaches the problem by more indirect methods. He has incorporated the "monkey-wrench effect" into his theory — as the uncertainty principle which has roused so much misplaced excitement among the philosophers. And he has also refined his equipment, in order to make the monkey wrenches as small as possible.

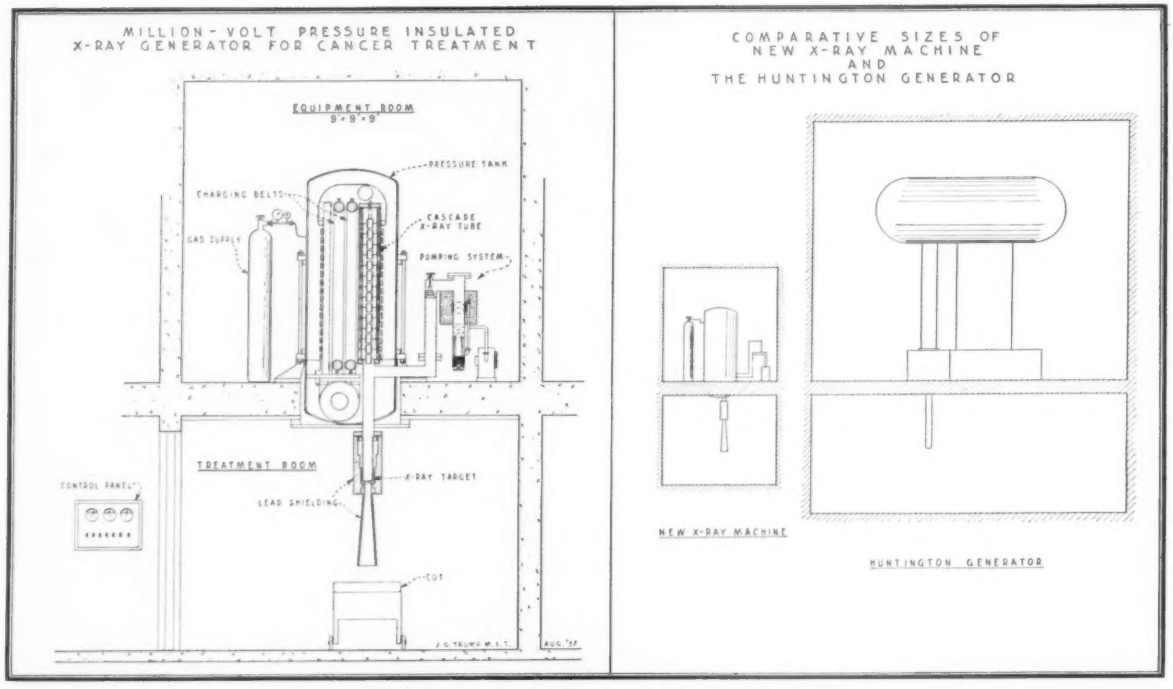
Similar efforts are needed in biology to circumvent the damage an experiment produces on the organism studied. Biology is too little developed as yet to have much underlying theory, but the monkey-wrench effect will probably play an important role in the theory as it is developed. Meanwhile biologists are striving to refine their tools, in order to study organisms by methods having the least possible damaging effect. In this struggle the new techniques developed in physics are proving decided aids.

For instance, new electrical devices, in particular the various types of vacuum tubes, make it possible to measure exceedingly small currents and voltages. Since every biological change involves minute electrical changes, it is found that electrical measurements, which involve little damage, can be used to indicate and to measure indirectly the underlying biological processes. The study of the electrical waves accompanying heart action has progressed far enough so that the electrocardiogram is useful in diagnosis. Other similar studies are being made, but only a few have acquired the mass of correlated data necessary before any device can be used as a biological indicator.

Exceedingly interesting studies are being made of the mechanism of nerve conduction, the central problem in the study of the organization of life in the higher animals. Electrical impulses accompany nerve signals, and a study of these pulses, which are sometimes spasmodic, sometimes almost periodic, is proving of considerable value in the understanding of the abilities and limitations of our internal telegraph system. The much publicized encephalograms, the so-called brain waves, are probably related to the nervous turmoil in the brain which we call thought; but the phenomenon is so complex that a great deal of work is necessary before the

NEW TOOL FOR PHYSICIANS

To facilitate observations of heart rate, the new research laboratories of biological engineering at M.I.T. have applied the latest developments in electronics to obtain the cardiotachometer. Connected by means of flexible electrodes, applied in this instance to the arms, the voltages accompanying muscular action of the heart are caused to operate a meter which gives a direct reading of the pulse rate and shows temporary changes in rate which cannot be observed by other means. It is particularly useful with small animals, such as laboratory mice, in which the rate is too high to be counted directly. The cardiotachometer is now being applied in operating rooms as a tool of the anesthetist



NEW STYLES IN MILLION-VOLT X-RAY GENERATORS

A new x-ray generator, to equal in voltage and output the highly successful million-volt unit completed by M.I.T. for Boston's Huntington Memorial Hospital last year, but to occupy less than one-tenth the space required by it, is now under development in the high-voltage laboratories of the Institute. The new generator will rely upon insulation by gas under pressure and consequently will not require the housing space necessary for safe operation in air at ordinary pressure. At the left is shown a sectional view of this new generator, while at the right is graphically shown the economy of space achieved since the new generator was designed

measurements will be of direct use to biology or psychology. Much of this work is being carried out at Tuxedo Park, N. Y., by Dr. Alfred L. Loomis, the banker who is also a top-flight physicist.

The same conclusions must be made about the exceedingly interesting work of Professor J. Warren Horton,'14, here at Technology, on the electrical impedance of the human body. The preliminary results seem to indicate that this impedance is an indicator of general bodily well-being; but the possibilities and limitations of the method can be determined only by an accumulation of vast amounts of data. Similarly, certain work at Yale and at the Harvard Medical School, showing that there is a measurable electrical fluctuation accompanying ovulation, gives some promise of aid in the immensely important study of human fertility. This is also receiving much more investigation.

Other physical techniques are likewise proving useful. The utility of ultraviolet light is now established, as is also the fact that there are definite limitations to its use. Ultraviolet exerts its effect only at the surface of an organism; an attempt to penetrate deeply below the surface would involve such intensities as to produce a supersunburn on the surface. X-rays, however, can penetrate much more deeply without injuring the surface, although if the intensity is too great, the injury is more serious. One of the important medical advantages of x-rays is that the injuries are selective — cancerous growths, for instance, being slightly more susceptible than normal tissue. The difference is only slight, however, and it often happens that in order to affect a deep-seated growth, so great an intensity would have to be used that the normal surface tissue would be harmed.

The solution of this difficulty is to use x-rays of greater penetrating power, of shorter wavelength, and requiring higher voltages. One of the pioneers in this field is the million-volt outfit at the Huntington Memorial Hospital, Boston, built by Professor John G. Trump, '33, one of Professor Van de Graaff's colleagues here at Technology, and turned over to Dr. Richard Dresser, who has supervised the medical use of the equipment. It has been in operation only a year, but the number of successful treatments already made indicates its extreme usefulness. It is possible that even higher voltages will be practical and useful. Professor Trump is at present building a much more compact x-ray outfit, using compressed gas for insulation, which should deliver somewhat more than a million volts.

The other use of x-rays, to make shadowgraphs of organisms for diagnosis and study, has long been employed and is constantly being extended. It constitutes an earlier gift from physics to medicine.

By far the most exciting possibilities for future applications to biology, however, lie in the artificially radioactive substances which are now being discovered. Corresponding to practically every chemical element, there have been found one or more radioactive isotopes of the element. Atoms of these substances are indistinguishable by chemical means from normal atoms of

the element. Their difference lies in their latent instability. Sooner or later an atom of the radioactive isotope explodes, its inner nucleus shooting off radiation similar to that from radium and changing during the process into the nucleus of a different chemical element. An atom of a radioactive isotope is thus the black sheep of the family, having outwardly the same family characteristics as his normal brothers and sisters but being likely to disappear at any moment, leaving a cloud of scandal behind. These unstable brothers are created by bombarding normal substances with high energy particles or with neutrons, which are in turn produced by high energy particles. When the large electrostatic generator at Technology is set up for the generation of artificially radioactive substances, it will be able to produce large quantities in relatively short times.

Some of these substances are extremely precocious, going amuck a few minutes after birth, not leaving time enough for their properties to be used. Many isotopes, however, last for a day or a week, and enough more kinds are being discovered each month to make it reasonable to expect that most of the important chemical elements will have at least one kind of relatively long-lived radioactive brother. If a few atoms of such a substance are placed among a large number of their normal brothers and sisters and the whole family is injected into an organism, each unstable brother will stick with the family until he blows up. The effects of the explosion can be detected by any of a variety of vacuum tube devices. These explosions tell us the location of the radioactive atoms and, what is more important, the locations of their normal brothers and sisters. To change the metaphor, we now can tie a radioactive bell to our normal chemical cat, so that we can follow its otherwise silent motions through the organism. When we remember the immense importance small amounts of chemicals have on the organism and when we realize the difficulty of following their flow (since we cannot change their rate of flow much without killing the organism), we can see that the possible uses of the radioactive tag method in biological research are almost unlimited.

Examples of the sort of experiments which can be done will make the possibilities more clear. Phosphorus has a nice radioactive brother, fairly easily produced by the bombardment of sulphur by neutrons and having a mean life of about two weeks. Suppose we mix a minute amount of the radioactive phosphorus into some normal phosphorus, in such a proportion that one exploding nucleus a second would indicate the presence of one microgram of phosphorus (about twenty quadrillion atoms of normal phosphorus), one explosion a minute would indicate $\frac{1}{60}$ of a microgram, and so on. Now suppose we feed an animal a few grams of this "labeled" phosphorus some morning and, after waiting for a day, or a week, or whatever length of time we wish to study, take a small sample of a tooth of the animal and count the number of telltale nuclear explosions per second. This number tells us directly how many milligrams of the labeled phosphorus have traveled through the animal during the time studied and have eventually settled down on the sample tooth. (*Continued on page 376*)

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The Great Detective Story

M.I.T. Photo

Old Ways and New in the Discovery of Oil

By Roland F. Beers

Adding a Billion Barrels Yearly to Our Oil Reserves — The Sly and Ingenious Detective Techniques of the Geophysicists — Are They Adequate to Maintain Oil Supplies for the Future?

THREE million, three hundred thousand barrels of oil! That is the daily order for the nation's supply of crude petroleum. To fill this order unfailingly means that each year more than 1,000,000,000 barrels of oil must be added to the nation's reserves. In 1937 the known and proved natural petroleum reserves in storage and in the ground were estimated to be 13,000,000,000 barrels — enough for ten years' demands. This figure represents, in a measure, the success of those who are charged with the responsibility of maintaining an unceasing flow of this important fuel.

The first well to produce petroleum in commercial quantities, drilled primarily for this purpose, was the famous Drake well at Oil Creek, Pa., which, in 1859, reached a depth of 69 feet. Its initial production was 25 barrels per day by pumping. Since that time the United States has produced and discovered approximately 30,000,000,000 barrels of petroleum, 90 per cent of this amount having been discovered within the last 35 years. With the price of oil averaging one dollar per barrel, the scope of this production places the petroleum industry among the greatest of the nation. Further idea of the capital investment of the industry may be had from the amount of crude oil in storage above ground. On April 2 the Bureau of Mines estimated this to be 308,237,000 barrels. On April 3, 1937, the corresponding figure was 298,163,000 barrels. In Texas, our greatest oil-producing state, average daily production has increased from 100 barrels in the year 1897 to 1,378,000 barrels per day in 1937. In the famous East Texas field, largest in the world, the 25,000th well was completed recently.

On December 31, 1936, the total number of producing wells in the United States was estimated at 350,000, of which 25,166 were completed in 1936. The total production in the United States during 1936 was 1,098,516,000 barrels; that of the world was 1,700,271,000 barrels.

The magnitude of such figures is so far from the experience of most of us that these statements have little meaning. The scale of the entire industry is gigantic, and frequently oil talk hears that the unit of exchange is a million dollars. In spite of the overwhelming effect which such a scale of operations produces, it is possible to realize that here is one of the most orderly and scientifically planned industries of the nation. In all phases of the industry is found competent and energetic management. The ability to regulate its conduct by self-enforced measures is an index of this efficiency.

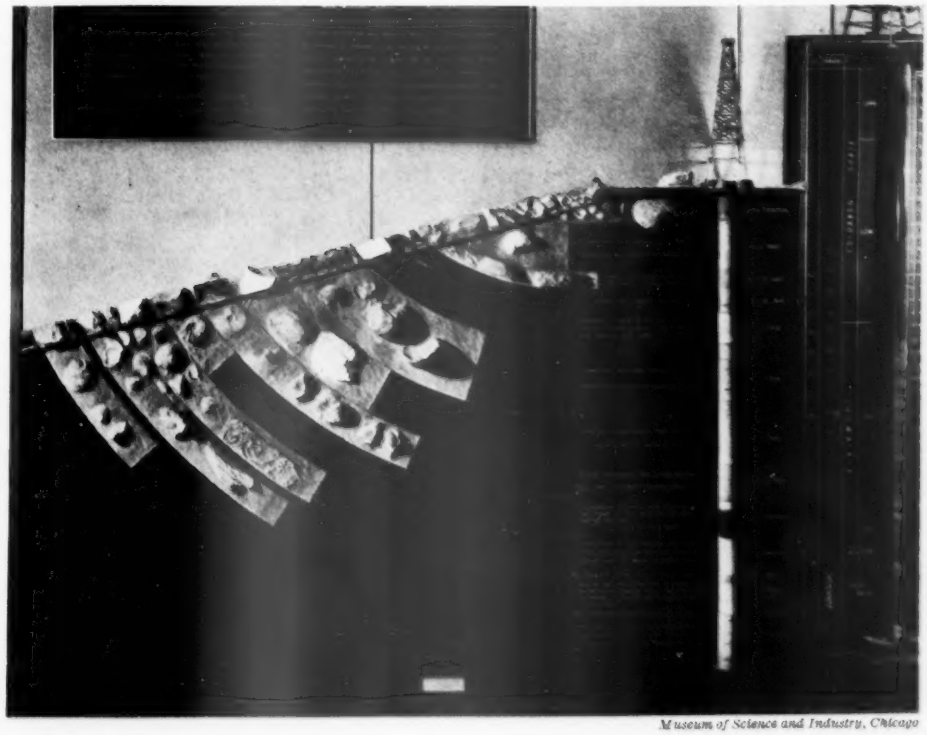
Depending for its very life upon a continuous supply of petroleum at reasonable cost, it is not surprising to find a major portion of the industry's attention centered in the production division. Few other industries are comparable in the degree and perfection of organization in the producing divisions of oil companies. In the matter of exploration alone, with which this article is primarily concerned, you will find long-term policies and plans in use. In the mining industry where exploration has been carried out largely by local prospecting in a random manner it is equally important to utilize all possible aids.

Major oil companies employ plans which frequently embrace entire states, without actually owning any considerable acreage in the areas under exploration. The net effect of these long-term programs, supported by large amounts of organized capital, has been the thorough development of the science of exploration. The stability given to this scientific field has been substantial enough for men of great talent to have been willing to devote their entire lives to its cause. With a growing opinion that the petroleum reserves of the nation may dwindle in the future, the drive for additional discoveries has been greatly intensified. In this program all the tools of modern research are being employed without stint. As in other phases of scientific investigation, the field is now divided into highly specialized zones over which preside men of special talents and training.

The attitude of the modern explorer for oil is not unlike that of the medical diagnostician. If you suspected that you were not well, although no outstanding symptoms presented themselves, you would probably consult your medical adviser. He would examine your condition carefully, employing perhaps a dozen instruments or methods of diagnosis. Among these might be cited at random the measurement of your body temperature, pulse rate, respiration, and weight. He might employ a stethoscope to listen to the sounds of your heartbeat or he might take an electrocardiograph for further diagnosis. Recent advances in medical research employ the measurement of the impedance of the body together with electrical records of the microvoltage waves generated by the brain and nervous system in action. The explorer for oil has at his command no less a comprehensive array of methods and equipment. Before going into these items in detail, let us trace briefly the concepts which lie behind the accumulation of petroleum in commercial deposits.

Early in the history of petroleum exploration a theory was developed which, with slight improvement, forms the basis today of all petroleum discoveries. This theory stated briefly that deposits of petroleum or natural gas might be found at the crests of ridges or domes in folded rock strata, due to their natural separation by gravity from the subterranean waters with which they are invariably associated. Soon after the successful establishment of the anticlinal theory in West Virginia, the search for these structural features in other areas became extensive. Up to the year 1925, practically all geological exploration in search of petroleum was directed toward a search for structures.

The methods of locating such structures are well known, but a brief outline of their application may serve to make the story complete. Anticlines are believed to have been formed by the action of stresses in the earth's crust incidental to mountain building and other tectonic forces. The causes of these stresses are diverse, and all that we need to recognize here is the fact of their



Museum of Science and Industry, Chicago

THE CORES

. . . shown under the drilling derrick in this exhibit come from East Texas fields and illustrate the manner in which the geologist examines the stratification of an oil region. Note that the dark brown sample is the "oil sand." The various rock layers can be identified by their fossil content, some outstanding specimens of which are shown on the left of the exhibit

Museum of Science and Industry, Chicago

Exhibit illustrating the use the geophysicist is able to make of the fact that rocks differ in density. Note the accumulation of oil in an anticline in the central diagram and below, the salt dome structure, along the sides of which the oil pools have formed *(see opposite page)*

existence. Since the portion of the earth's crust with which we are concerned is composed of layers of different formations, the folding caused by these stresses frequently forces ridges and domes above their natural elevation. Many such structures formed in the past are now visible at the top of the ground, and the geologist, by making measurements of the elevation above sea level of one or more continuous strata, can determine the extent to which such beds have been folded. By mapping a sufficient portion of the disturbed area, he can determine whether such folding has produced a closed structure, that is, one around which closed contours, showing planes of equal elevation, can be drawn. The keynote of his search is therefore closure. At the present time practically every acre of the petroliferous provinces of the United States has been subjected to surface geological surveys of this type. Many areas have been surveyed repeatedly for evidences which escaped early attention.

Supplementing the work of surface geological parties, there has also been considerable use made of aerial photographs. Because the nature of soil and vegetation often changes with the type of geologic formations exposed at the surface, these photographs frequently give striking evidence of geologic structures which are not noticeable to an observer on the surface of the ground. Oklahoma City, Okla., and Kettleman Hills, Calif., are outstanding examples of fields observable by this means.

Sooner or later the geologist comes to areas where surface formations are not adequately exposed for the completion of his survey. In some instances resort is then had to the digging of shallow holes by means of hand augers or to the use of trenches. The purpose of such procedure is, of course, the exposure of key beds in salient positions. A widespread program employing these methods has the additional advantage of yielding data in points where needed rather than in points where exposures are more or less accidental. The extension of this phase of the work leads naturally to core drilling, which embraces all means of obtaining, by drilling methods, samples of rock formations below the surface of the earth. This practice was commercially developed in 1917.

By the end of 1915 practically every oil company in the field maintained a comprehensive geological department. The primary basis of oil exploration at that time was geological and, as has been pointed out elsewhere, fortunately this science was then developed to a point where it would be of real use to the industry. At the present time the science of exploration is in the hands of groups of technicians numbering in excess of 3,000.

At about the same time a noteworthy advance was made which greatly enhanced the utility of the geologist in the location of buried structures. This was the employment of information obtained in drilling wells for the development of subsurface geologic maps. Later another tool was added in the use of micropaleontology, the identification of sediments through study of microscopic animal remains.

In addition to the trap for petroleum deposits afforded by the closed anticline, geologists have come to recognize the existence of traps closed by other agencies. Closely allied to the anticlinal trap is that of the faulted structure wherein closure on at least one side is afforded by the vertical displacement of the entire geologic section on one side of the fault. Many faulted structures are readily observed at the surface of the ground, an outstanding example of this type being the Mexia-Powell fault zone of Texas.

The geologist, in making his studies of surface and subsurface formations, is dependent upon the availability of suitable data in the proper location. Surface formations outcrop and offer exposure at locations which may not meet the geologist's requirements for distribution. The cost of drilling deep wells for geologic data alone is too great for widespread use. Not unnaturally, therefore, in 1922 tools and methods were brought into use from fields foreign to that of the geologist, and a new combination of sciences — geophysics — sprang into prominence. The earliest of these efforts was the importation from Hungary of the torsion balance, which measures changes in the distribution of gravity at the surface of the earth. In 1924 the first Texas salt dome was discovered by the use of this instrument. The gravity anomalies offered by the low-density masses of salt which had intruded into the heavier sediments of Texas and Louisiana Gulf Coast were centers of intense interest from 1924 until 1930. Since that time less ob-

vious anomalies of the gravitational type have been discovered in the Gulf Coast provinces with more refined technique. It is now held that merely the uplift of overlying sediments by very deep salt plugs may be the basis of many of these anomalies. Inasmuch as petroleum deposits are contained within the sedimentary formations overlying these domes, as well as on the flanks, many of the deeper structures have developed great production.

At the present time considerable use for reconnaissance purposes is being made of the torsion balance, the gravity pendulum, and gravimeter in all petroliferous areas of the United States. The basis of many of these surveys is frequently conjectural and yet with the difficulty in discovering new fields no advantage should be overlooked. Because of the relatively low cost of gravity reconnaissance surveys, their use is frequently a standard practice, and they form one of the important methods of diagnosis.

In 1924 the use of the refraction seismograph was introduced into the United States for the purpose of detecting the presence of salt domes by virtue of the enhanced speed of travel of sound, or seismic waves, through salt. Since the average velocity of propagation of sound through Gulf Coast sediments ranges from 6,000 feet to 12,000 feet per second, whereas that through salt masses is of the order of 16,000 feet per second, a high degree of differentiation is available. The success of the refraction seismograph in the years 1924 to 1930 has never been, and probably never will be, achieved by any other single method of exploration.

The attempt to map stratigraphy in geologic provinces characterized by sharp planes of sedimentation was a logical development of the use of the seismograph for the location of salt dome structures. Propagation of sound through a stratified medium is essentially a problem in geometric optics, and once the possibilities were suggested, the method became exceedingly powerful in areas where the degree of stratification was sufficient for its application. One of the most notable programs of geophysical investigation was carried out along this plan in the Permian Basin of West Texas and New Mexico during the years 1928 to 1931. In this province the presence of thick beds of rock salt and anhydrite offered ready means of differentiation from the overlying low-velocity red beds. An unanticipated discovery of the stratigraphy of this region was the further increase in velocity of sound shown by Permian limestones.

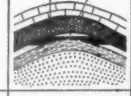
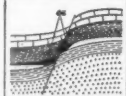
Through the continued application of the *refraction* seismograph to the delineation of structural features, the principle of the *reflection* seismograph was developed. This instrument achieves the determination of the depth of any of a series of hard-rock formations overlain by those of lower velocity, because a sharp echo, or reflection, is produced when a sound wave encounters the interface. By determining in advance at the location of a well the average vertical velocities in the geologic section, it is possible by timing the travel of the reflection wave to determine the depth to the reflecting horizon. A geophysical survey employing this method is essentially a step-by-step method wherein a prospect is covered with a network of points sufficiently dense to permit evaluation of the structural (*Continued on page 380*)

Museum of Science and Industry

Exhibit illustrating the manner in which magnetism aids the geophysicist. The oil above the intrusion in the center was located because limestone is less magnetic than granite, a fact of value for the Midcontinent and Mississippi Embayment province (*see page 385*)

Below. *Table prepared for the American Petroleum Industries Exhibit at the 1933 Century of Progress in Chicago*

CHOICE OF GEOPHYSICAL METHODS IN OIL PROSPECTING

				RECONNAISSANCE	DETAIL	
LOCATION OF POTENTIAL OIL STRUCTURE	TECTONIC	ANTICLINES		4	1	REFLECTION SEISMIC
		DOMES		1		MAGNETIC
		MONOCLINES		3	3	TORSION BALANCE
		TERRACES		(3)	3	REFRACTION SEISMIC
				(3)		PENDULUM
				4	4	RESISTIVITY, INDUCTIVE
		FAULTS		1	1	REFLECTION SEISMIC
				3	(3)	TORSION BALANCE
				(3)	(3)	MAGNETOMETER
					(3)	REFRACTION SEISMIC
				(3)	3	RESISTIVITY
					(3)	INDUCTIVE
	VOLCANIC	DIKES INTRUSIONS		1	1	MAGNETIC
				3	3	TORSION BALANCE
				3	3	SEISMIC
	SALT	SALT DOMES, SALT-ANTICLINES		1	3	REFRACTION SEISMIC
				4	1	TORSION BALANCE
					3	REFLECTION SEISMIC
				3	3	RESISTIVITY, INDUCTIVE
				(3)		PENDULUM
	BURIED RIDGE	GRANITE RIDGES OTHER BURIED TOPOGRAPHIC FEATURES		1		MAGNETIC
				2	3	TORSION BALANCE
				(3)	1	REFLECTION SEISMIC
				3		PENDULUM
	LENSING	(HOGBACKS)			1	RESISTIVITY, MAGNETIC
DIRECT LOCATION OF OIL	IN WELLS		SEE CHART IN N.E. CORNER		1	ELECTRICAL CORING
	FROM SURFACE		PROVEN ONLY FOR SHALLOW DEPTHS			RESISTIVITY

Black Star

This cucumberlike structure is a German spinning tunnel. Within, free-spinning models are kept in suspension by the air stream to devise full-scale designs capable of pulling out of dangerous spins

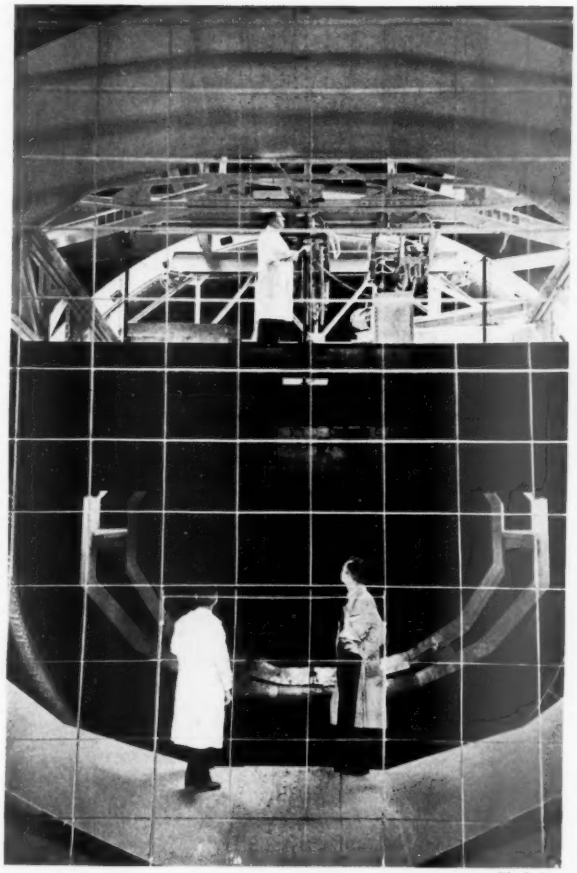
Pictures, Inc.

Wind Tunnels Are Spectacular

AND they are monuments to man's failure to solve a series of equations — the equations of motion of a slightly viscous fluid such as air. Because these equations have not been solved, the aeronautical engineer must derive much of his data from wind-tunnel experiment rather than from what the experimentalist wryly calls "pencil pushing."

A few tunnels, like that at Chalet-Meudon and the great 60-foot one at Langley Field (see opposite), are large enough to permit a limited study of full-sized aircraft under controlled conditions, but the excessive cost and power involved in these great plants prevent them from being duplicated. Most tunnels, therefore, are built for models — the study of flight in miniature — and here the engineer comes up hard against that famous index in fluid mechanics known as the Reynold's number. The model under test should have the same R.N. as the full-sized plane it represents; *i.e.*, for the model and for the full-sized plane, the product of speed, wing spread, and air density, divided by the air viscosity, must be the same.

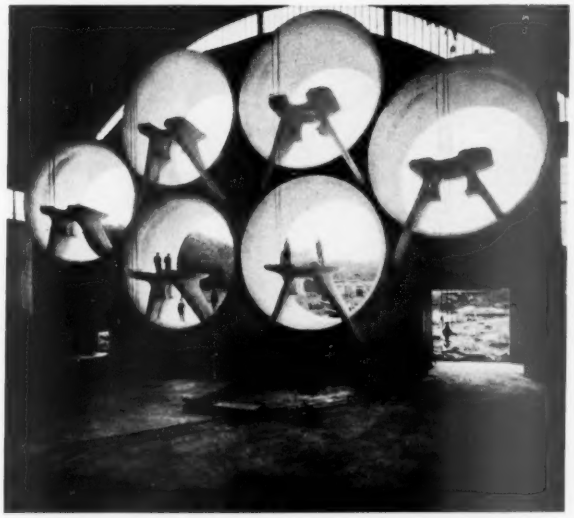
Conditions yielding a Reynold's number comparable to full-scale flight are obtained by varying the pressure within a closed tunnel. For a description of the Wright Brothers tunnel, the latest effort to control the Reynold's number over a wider range of conditions, see the second page following.

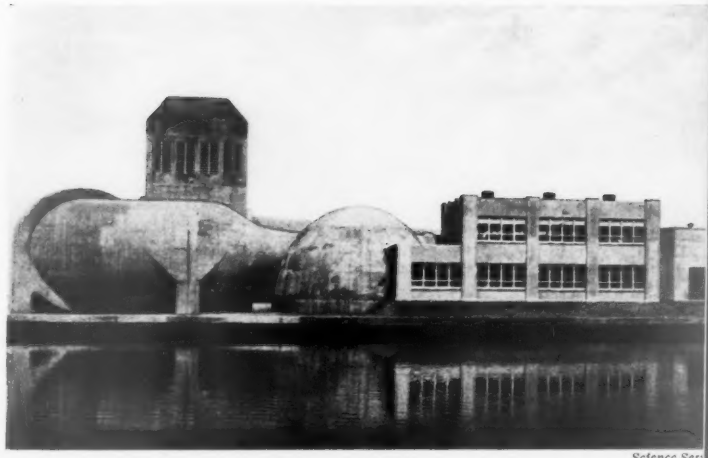


Black Star

Above and opposite. *Interior views of the return-current, open-jet wind tunnel of Göttingen. The vanes shown on the opposite page direct the air around one of the four bends in the tunnel. The open-jet area, where the model to be tested is suspended, is shown above.*

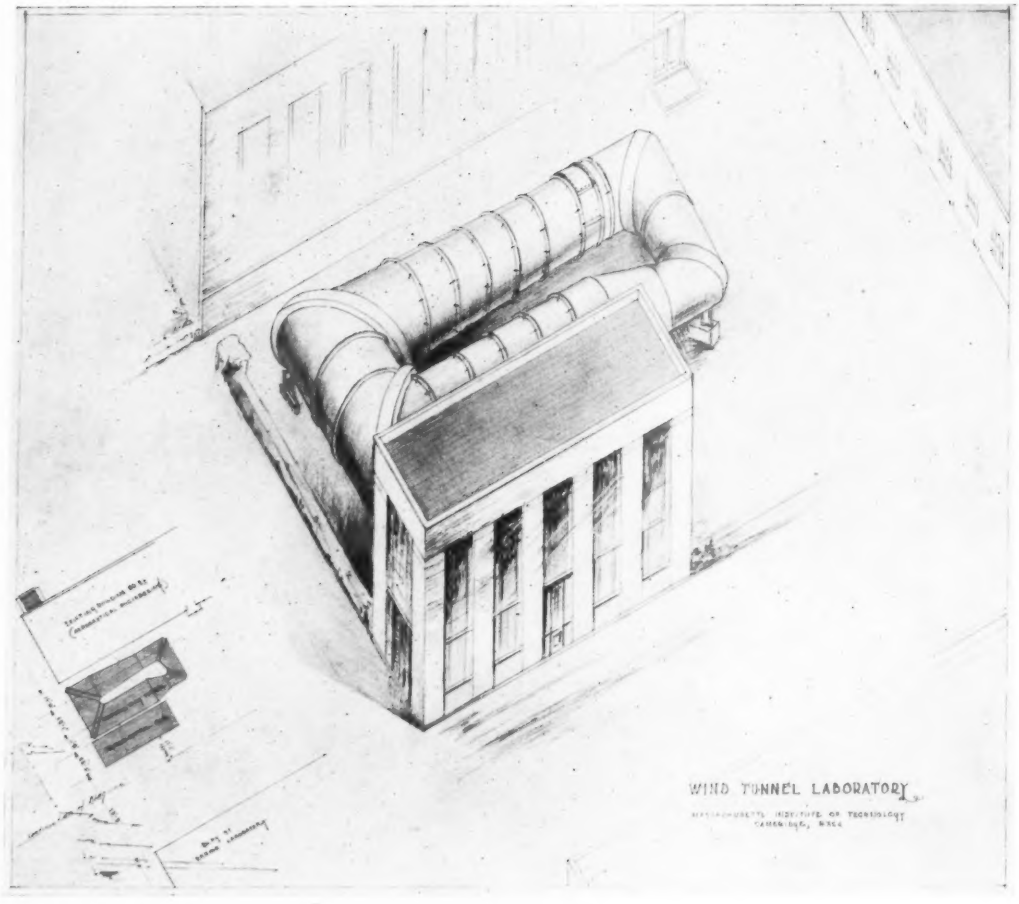
Right and below. *The huge tunnel built by the French Aeronautical Technical Service at Chalet-Meudon to test full-sized planes. At the right is the intake and below is the housing for the six propellers that pull air through the tunnel at 113 miles per hour*





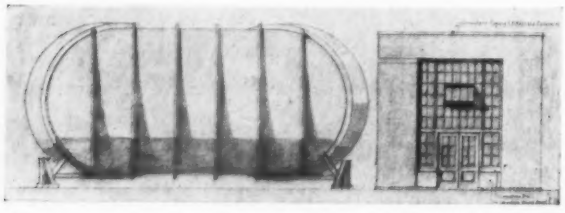
Science Ser

Above. *The great compressed-air tunnel built at Langley Field by the N.A.C.A. In such a closed tunnel it is possible, with accurate models, more nearly to reproduce the conditions of full-scale flight*



The Wright Brothers Wind Tunnel

THIS new tunnel (of which a prospective drawing and the south elevation are shown), now under construction at M.I.T., is designed to provide a wider range of conditions than any existing American wind tunnel offers at present. It will develop wind velocities up to 400 miles an hour and simulate variations in barometric pressure up to theoretical altitudes of 35,000 feet — capabilities that presage advances in aeronautical engineering research. The tunnel may be operated under pressures up to four atmospheres, which will yield a Reynold's number comparable to full-scale flight, or it may be operated below atmospheric pressure, enabling studies to be made of substratosphere flight at high speed. The tunnel will thus be unique, in that it combines means for operating at a high Reynold's number to study skin friction, turbulence, and flow separation with means for study of high-speed phenomena. Two thousand horsepower will be available to drive the fan.



Wind tunnels such as this one are useful not only in aeronautics; they are helpful in the design of any kind of machinery that handles fluids, such as fans, windmills, turbines, and pumps, and they are useful in instructing future aeronautical engineers in the mysteries of aerodynamics.

With the increasing speed and size of aircraft, our existing wind tunnels have become obsolete. In this country only the great Langley Memorial Laboratory of the National Advisory Committee for Aeronautics has equipment operating near full-scale R.N.

This new tunnel doubtless will not be available for such ulterior use as the one recently suggested by a national magazine. A bright young editorial writer sought vainly to borrow a wind tunnel in which he could suspend several women and determine the amount of wind velocity necessary to remove from their heads and blow to destruction the currently popular chin-strapped hats.

Converting Sunlight into Power

The Cabot Solar Energy Fund and the Exciting Research Program It Will Support

A QUEST for methods of harnessing the inexhaustible energy of the sun in the form of useful power is about to begin in a broad program of chemical, physical, and electrical research at the Institute. This great undertaking, the potentialities of which stagger the imagination, is made possible by the foresight and generosity of Godfrey Lowell Cabot, '81, a life member of the M.I.T. Corporation, whose long interest in solar energy prompted him to offer Technology a capital gift of $647,700 for studies in this field.

The income of Dr. Cabot's gift, which will be known as the Solar Energy Fund, is to be devoted specifically to a long-range search for direct methods of converting the sun's energy into power or storing such energy for future use. After 50 years the income of the fund may be used for such other purposes as the Corporation of the Institute may select. In beginning this solar energy research program, President Compton and Dean Bush, '16, propose to enlist the coöperation of numerous senior members of the present staff who, with additional assistants and special equipment, will have the opportunity to accelerate and expand current research projects bearing on this exciting field, advance their own studies, and at the same time guide students in a research of great educational value.

The enormous potential power in solar energy is revealed by measurements which show that solar heat reaches the earth in the Temperate Zone at the average rate of about 4,000,000 calories per square yard per day. During the three months of greatest sunshine, an acre of land receives directly from the sun an amount of heat equivalent to burning approximately 250 tons of high-grade coal. This measurement indicates that unobstructed solar radiation, transformed completely into useful energy, would produce approximately one horsepower per square yard. The heat output of the sun in a year has been estimated by Charles G. Abbot, '94, Secretary of the Smithsonian Institution, to be equal to the burning of 400,000,000,000,000,000,000,000 tons of anthracite coal.

This energy determines our climates, causes winds, ocean currents, and rainfall, and produces photochemical reactions whereby a portion of the energy is stored in plants. Thus, solar energy is the ultimate source of our fuels—wood, coal, oil, and gas—as well as of power derived from wind or falling water. However, the stores of fuel energy in coal, oil, and gas, while great, are not inexhaustible. It is therefore of ultimate importance to investigate and develop alternative sources of heating and power. Furthermore, there are situations where other sources are even now more advantageous, and undoubtedly such possibilities can be extended by further study.

To this end Dr. Cabot established at Harvard University, in 1937, the Maria Moors Cabot Foundation for Botanical Research for studying the growth of trees or other plants, with primary interest in increasing the storage of solar energy in the form of fuel as a plant product which can be grown as a crop. The present efficiency of plants as converters of solar energy into fuel energy is such that in favorable circumstances about two- or three-tenths of one per cent of the sun's energy falling on a tract of land in the growing season can be captured by plants grown on the land.

Recognizing that economic utilization of solar energy is possible through agencies other than plant fuel and desiring to establish the research program on such a broad basis as to seek solutions from all promising avenues of approach, Dr. Cabot established the Solar Energy Fund at the Institute to promote and support efforts to make solar energy economically available through application of physical, chemical, and engineering principles.

Because of the enormous amount of solar energy freely available, the practical problem is not to find means of using it with a high percentage of efficiency but rather to find methods that will be cheap enough to make solar energy economically useful. To this end

Berkeley

GODFREY LOWELL CABOT, '81

. . . who has made a capital gift of $647,700 to Technology to initiate and support a research program in the utilization of solar energy

the first objective will be to determine whether the direct use of sun energy is now economical and feasible and, if so, where, for what purpose, and under what conditions. This will involve the evaluation — on the basis of first cost, maintenance, and output — of those devices for this purpose already proposed, studied, and published by scientists everywhere. This first objective will also require a study of new designs in order that they may be better adapted for their purposes. A second step will be a study of the feasibility of developing new conversion equipment, utilizing phenomena at present under study in physical and chemical laboratories and of ultimate promise in economical sun-energy conversion. A third phase will be a long-range basic development of knowledge of phenomena at present under study, which may become practical for sun-energy conversion in the more distant future. This might be brought about through changes in the general economic value of our present sources of heat and power or through improvement of the efficiency and lowering of first cost of equipment based on unusual physical and chemical processes.

In order that the solar energy research may have the highest educational value, student investigators will have opportunities to participate in it, under the guidance of members of the Faculty who will be in charge of various phases of the investigation. Thus the Institute's long-established plan of coördinating professional education with research will be extended into a new and promising field of knowledge.

The solar energy research program contemplated by the Institute may be divided into three major fields of investigation. The first of these is a study of means for utilizing solar heat to operate engines to deliver mechanical power. The second is the possibility of employing electrical apparatus for converting solar radiation into electrical energy. The third will consider chemical conversion of sunlight into forms available for work.

The approach to the problem of heat engines holds exciting possibilities, for so far as is known no comprehensive scientific study of the subject has ever been made. There have been many attempts in which mirrors were used to concentrate sunshine as a source of energy for heat engines but, while some of them have been technically successful, they were economically unsound. The problem of economically collecting the sun's heat is a baffling one and should not be circumscribed by the requirements of engines of conventional conception. It is proposed, therefore, to approach the study by considering engine design and development of the heat collector as a unit problem.

The study of engines capable of effectively using the collected solar energy contemplates machines capable of operating on a low upper temperature and with a comparatively small temperature range, of small first cost and maintenance per horsepower hour of output. Engines having this low-grade heat input may deliver their output in several forms, such as mechanical power on a shaft, or in the form of compressed air. Two types of engine invite immediate study. The first is a vapor power plant, similar to the steam engine but using liquid of higher vapor pressure than water. This type might be either a reciprocating engine or a turbine. The other is a modernized hot-air or caloric engine which might be used to supply compressed air or mechanical power.

Research on electrical apparatus for utilizing solar energy suggests three interesting approaches. These are vacuum or gas-filled photoelectric cells, thermopiles, and boundary-layer apparatus, such as the copper-copper oxide cell. None of these has been successfully adapted to convert sun energy for power purposes. Although all are notoriously inefficient, one cannot assume that further knowledge and its application may not entirely change the situation. If it should, the possibilities are enormous.

The photoelectric cell, in its present form, seems to have an upper limit of efficiency which is far too low. However, there are new forms appearing which are worthy of serious study. The thermopile appears to be limited in efficiency by the Wiedemann-Franz Law, but there may be special forms to which this does not apply. The thermopile is not a promising energy-conversion apparatus for fuel firing. In sun-energy conversion, where efficiency is secondary, the problem is reduced to one of over-all cost per unit of output. This aspect does not seem to have been seriously studied.

Boundary-layer equipment is evidently in its infancy. An essentially empirical approach has produced useful equipment, and there have been popular descriptions of its possible use for transforming sun energy. The primary need in the attack on this problem is more basic knowledge. Specifically, science needs to know more about the behavior of electrons and ions in solids and especially at boundary layers. The development of such knowledge may well be accompanied, as it proceeds, by frequent practical studies of possible applications. It is evident today, however, that much more information is needed before specific applications can be successfully planned. On the other hand, the ignorance is so vast at present that there remains the possibility that developments in this direction may supersede many other means of power conversion and provide an inexhaustible source of cheap power. Some unique phases of research in this field of boundary layers are now being vigorously prosecuted at the Institute.

Chemical conversion of radiation into useful forms of energy is considered one of the important approaches to the utilization of sun power. There is the possibility of eventually discovering chemical compounds that can absorb sun energy and convert it into stored energy for economical power production. In such studies of the reactions between organic compounds and radiation, the Institute's spectroscopic laboratory is expected to be of great assistance. Still another approach lies in the pioneering research on colloids now being carried on in the Department of Chemical Engineering.

To assist in the coördination and direction of this impressive program of fundamental research, President Compton has appointed a committee, the members of which are Professors Hoyt C. Hottel, '24, of the Department of Chemical Engineering, Arthur C. Hardy, '18, Department of Physics, Ernest H. Huntress, '20, Department of Chemistry, Arthur R. von Hippel, Department of Electrical Engineering, and George W. Swett, '03, Department of Mechanical Engineering.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Graduation

CHARLES D. MAGINNIS, the distinguished architect and now President of the American Institute of Architects, will make the Commencement address at the 71st graduation exercises of the Institute in Symphony Hall on June 7. A native of Ireland, Mr. Maginnis was educated at famed Cusack's Academy, Dublin, and also in England, where he was winner of the Queen's prize in mathematics at South Kensington. He came to the United States in 1885 and founded the firm of Maginnis and Walsh, a name which is associated with a number of notable ecclesiastical and college buildings in this country.

It is particularly appropriate that an architect should be asked to make the address, for this year's Class will include the last graduates in architecture to study in the original Rogers Building. In a few weeks that fine old structure will be a place of deep shadows, and next autumn the undergraduate architects will join the other Institute students in Cambridge. Then old Rogers, with its high ceilings and dark molded woodwork, Huntington Hall, and the Commons Room where once a forge flared, will have become part of Technology's history.

Following the custom of many years, Alexander Macomber, '07, has been chosen chief marshal of the graduation exercises, and the invocation will be offered by the Rev. Leslie T. Pennington, minister of the First Parish Church in Cambridge. Those graduates who are appointed second lieutenants will receive their commissions from Brigadier General William H. Wilson, commander of the First Corps Area. The officers of the 25- and 50-year Classes will, of course, have places of honor in the Commencement procession.

Ballot Results

DISTRESSINGLY small were the returns this year on the Alumni Association ballot, although the meager returns may be easily explained by the competition for attention provided by the Alumni Fund Campaign. It was nevertheless interesting to observe that the balloting for membership on the National Nominating Committee was highly competitive and very close. In District 8, William J. Sherry, '21, of Tulsa, Okla., was victor; in District 9, George M. Gadsby, '09, of Salt Lake City, Utah; and in District 10, Ernest B. MacNaughton, '02, of Portland, Ore. In one district the winner led by only 23 votes. Obviously the competitive plan for election to the National Nominating Committee is working well.

For offices which contained only one nomination on the ballot the recommendations of the National Nominating Committee, as recorded in The Review for March, prevailed. The new officers now ratified will be: for President of the Alumni Association, H. B. Richmond, '14; for Vice-President for two years, Raymond Stevens, '17; members of the Executive Committee for two years, Hovey T. Freeman, '16, and Edwin D. Ryer, '20; and for Representatives at Large for two years on the Alumni Council, Eric F. Hodgins, '22, Jerome C. Hunsaker, '12, Van Rensselaer Lansingh, '98, Winfield I. McNeill, '17, and Theodore B. Parker, '11. The three nominations for term membership on the Institute's Corporation were likewise ratified: Harry P. Charlesworth, '05, Marshall B. Dalton, '15, and Donald G. Robbins, '07.

198th and 199th

W. RUPERT MACLAURIN, Assistant Professor of Industrial Relations in charge of Institute work in this field, and Dr. Douglass Vincent Brown, also Assistant Professor of Industrial Relations, were the guests and principal speakers at the regular monthly meeting of the Alumni Council on March 28. Professor Maclaurin made a most interesting general presentation of this very timely subject, including the plans and objectives of the Institute work which differentiate it from that in other institutions which are studying the problem. Dr. Brown continued by dealing more specifically with the library material which is being gathered on the subject and with specific questionnaires which, having been circulated at one plant, developed some highly illuminating information.

The general subject of labor relations drew fire from the Council in a degree which has not been equaled since the lamented discussions on football. Prominent industrialists who were present were moved to defend themselves, and the whole discussion, in very friendly vein, was full of sparks of wit. During the business session it was voted to make the changes in the by-laws dealing with graduated life membership and class affiliations which had been officially presented to the Council with the minutes of the January meeting. These changes substitute for the present single life membership fee of $75 a graduated fee ranging from $75 at age 30 to $50 after the 55th birthday. In other words, the life membership fee has been placed on an actuarial basis and is therefore, under the new plan, a better and more attractive investment for Alumni.

The 199th meeting, held on April 25, was also graced by two guest speakers, this time from neighboring institutions. The subject for discussion was the relation of Alumni to a university, and this discussion was ably led by two men who are nationally famous for their work in alumni circles: Sidney C. Hayward, Editor of the *Dartmouth Alumni Magazine* and Secretary of Dartmouth College, and Herbert F. Taylor, Alumni Secretary of Worcester Polytechnic Institute and one-time President of the American Alumni Council. Mr. Hayward dealt particularly with the relations of Dart-

CRYSTALLIZED PHOTOGRAPHIC EMULSION

Each year the M.I.T. Faculty Club holds an exhibit of photographs contributed by members of the Technology staff and student body. Above and opposite are two prints drawn from the 1938 exhibition.

The above photograph, by John M. Holeman, '38, resulted when a microscope slide, coated with an experimental silver bromide emulsion, was accidentally left in an oven for three months. The silver bromide crystallized, and on development the crystals were reduced to metallic silver. To make the print, the slide was photographed with a photomicrographic camera onto two five-by-seven plates which were enlarged separately. Close examination in certain areas will disclose the shape of the individual crystals of which the pattern is composed. This is probably the first time that this phenomenon has been exhibited

mouth College to its Alumni. He explained the very interesting arrangement whereby there is an Alumni Council made up of representatives who actually get together from all parts of the nation once a year and the system by which Alumni take a very active part in the selection of students who are to attend Dartmouth.

Mr. Taylor spent some time in discussing the policies of Worcester Polytechnic Institute, whose problems, he rightfully stated, were quite similar to those of Technology. However, he enlarged the scope of his discussion to deal interestingly and amusingly with the proper relation of Alumni to an institution and traced the history of these relations: how Alumni were first ignored, how they then were seen as a good source for funds, how as a result of this they began to try to exert an influence in the conduct of the institutions and were for a time regarded by the heads of those institutions as a nuisance, and how today these relations have disappeared and the position of Alumni and administration is recognized as a mutually dependent one in which the Alumni are by no means only a source of money but a group whose advice and assistance in other directions is not only welcomed but courted.

Like the March meeting the subject of this evening evoked lively and interested discussion, largely in the form of questions.

New Awards

THE Order of Military Merit, newly established in the Institute's Department of Military Science and Tactics as an award for outstanding achievement in that Department, was presented for the first time to 49 freshmen of the Reserve Officers' Training Corps at a review of the entire regiment on May 2. The award is based on qualities such as military bearing and neatness, attention to duty, coöperation, initiative, judgment and common sense, and leadership. Award of the order will henceforth be an annual ceremony at the Institute. The awards were presented in the presence of Lieutenant Colonel Charles Thomas-Stahle, '22, Head of the Department, and Assistant Dean Thomas P. Pitré, who reviewed the regiment.

To Edward F. Miller, '86

JUST outside the office where for many years he sat wreathed in the blue smoke of his famous cigars and met his staff and students, a bronze tablet has been erected in memory of the late Professor Edward Furber Miller, '86, Head of the Department of Mechanical Engineering from 1911 until his death in 1933 and a member of the staff from the day of his graduation. The tablet has been placed opposite one erected some years ago in memory of the late Professor Gaetano Lanza, Head of the Department from 1883 to 1911 and a pioneer in the development of testing methods in mechanical engineering.

It is particularly appropriate that both these tablets were designed and executed by the Mechanical Engineering Department, in the early development of which both men had so important a part. The designs are by Professor Arthur L. Townsend, '13, who, with generations of other students of Professor Miller, recalls his

famous story of the cherry-red boiler, the hasty summoning of the expert (Professor Miller), and the happy aversion of a disaster. The patterns were made and the casting done in the Institute's own foundry, and the tablets were finished in Technology's machine tool laboratory. These tablets are two of a series being erected as a project of the Alumni Committee on Historical Collections, of which H. B. Richmond, '14, is chairman.

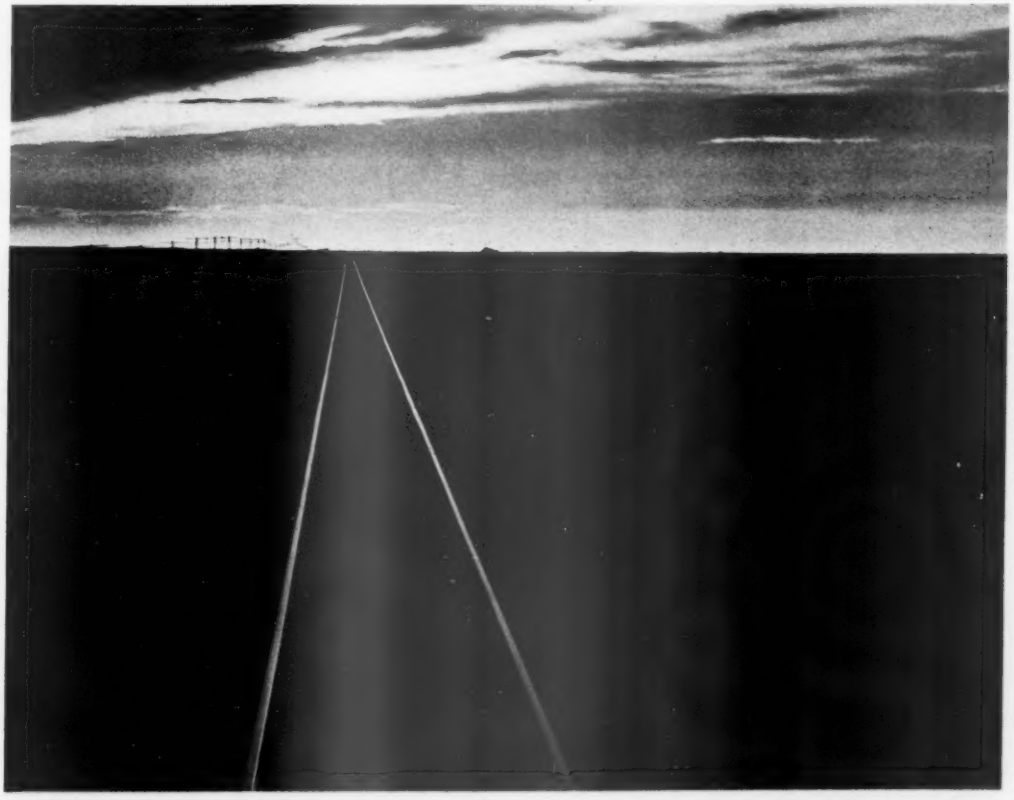
Elected

THE election of Warren K. Lewis, '05, Professor of Chemical Engineering, to the National Academy of Sciences at its recent meeting in Washington, D. C., brings to ten the Institute's membership in the academy. President Compton, who was elected in 1924, is now a member of the executive committee of the academy as well as of the executive committee of its government relations and science advisory committee. Vice-President Bush, '16, was elected to the academy in 1934. Other members are Professors Jerome C. Hunsaker, '12, Norbert Wiener, John C. Slater, James F. Norris, and Professors Emeriti William Hovgaard, Waldemar Lindgren, and Arthur E. Kennelly.

Conversion by Sunshine

RESEARCH on the effects of sunlight on health has brought agreement among a majority of specialists that a portion of the beneficial solar radiation causes the conversion of a chemical substance of the skin into the natural Vitamin D. This vitamin not only cures rickets in the young but has other beneficial effects on adults. The nature of the exact source of this chemical substance which, when exposed to sunshine, is converted into Vitamin D, has been debatable for some time and has been clarified by studies now being carried on at the Institute by Professor Nicholas A. Milas and Dr. Robert Heggie, '33, of the Department of Chemistry. These two scientists have produced this provitamin, as the chemical substance is known, by allowing enzymes isolated from fresh beef heart to act on cholesterol, a well-known solid alcohol manufactured by animal tissues and found most abundant in the brain and spinal fluids.

Pure cholesterol alone is not easily converted directly into the natural Vitamin D when subjected to sunshine or ultraviolet light. However, under the influence of dehydrogenating enzymes found in the body and in the presence of certain organic substances, the right number of hydrogen atoms are removed from the right position of the cholesterol molecule, and the substance produced is then easily converted into the vitamin itself by solar radiation or by ultraviolet light. This research has led the Institute's investigators to develop a simple process for the chemical production of this important provitamin directly from cholesterol, a process somewhat analogous to that carried on in the body. Vitamin D produced from this provitamin has been found to be more potent in human beings and considerably more potent when fed to growing chicks than the Vitamin D



SMOOTH RIDING FOR THE *ZEPHYR*

From a photograph shown in the Faculty Club exhibit by Alfred V. deForest, '11, Professor of Mechanical Engineering

M.I.T. Photo

HORN "ANTENNA"

A simple and efficient apparatus for producing a beam of ultra-high-frequency radio waves has been developed by Dr. Wilmer L. Barrow, '29, in the Department of Electrical Engineering at the Institute. This electromagnetic horn antenna is expected to be useful in microray communication over a narrow pencil-like beam at wavelengths only a few inches long. Other applications may be in airplane and ship navigation. Dr. Barrow is shown adjusting the transmitter by which the waves are started from the square hollow tube into the throat of the horn

produced by the irradiation of ergosterol, another solid alcohol which is manufactured by yeast and certain molds.

Horn Waves

A SIMPLE and efficient means of producing a beam of ultrahigh-frequency radio waves, in which a flared metal horn is used to project the waves into space in much the same manner as acoustical horns concentrate sound waves in a beam, has been developed in the communications laboratories of the Institute by Dr. Wilmer L. Barrow, '29. This new development in directive antennae was described by Dr. Barrow in a paper presented at the recent joint meeting of the Institute of Radio Engineers and the International Scientific Radio Union in Washington, D. C. The electromagnetic horn should find early application to microray communication, in which the intelligence is sent over a narrow pencil-like radio beam at wavelengths only about a tenth of a meter long. Other applications may be made to airplane and ship navigation, and similar uses for which these very short waves are adapted. This range of wavelengths, roughly below one meter in length, is rapidly being explored and put to practical use. Already this horn antenna is being applied to the blind landing of airplanes in a research carried on at Technology for the Bureau of Air Commerce. Several microwave communication channels have been in use in Europe for three or four years, the one across the English Channel being, perhaps, the best known. These microwaves and the horn antenna appear to be almost ideally suited for application to the blind landing of airplanes under conditions of fog, snow, or rain, although a further increase in the reliability and ruggedness of the sending and receiving apparatus is needed before the shorter microwaves can be advantageously employed.

The possibilities of radiating waves from electromagnetic horns was first described by Dr. Barrow in May, 1936, in connection with the transmission of telegraph, telephone, and television signals through hollow metal pipes. (See The Review for July, 1936, page 415.) Development of the horn was continued intensively from both experimental and theoretical angles. As a result it is now possible to design horns for particular applications with greater engineering precision than is possible for antennae of more conventional construction. One reason for the excellent agreement between calculations and experiment is that the waves are forced to follow the guiding surfaces of the horn straight out into space. Thus they cannot easily go back on connecting wires and supports, to be radiated in unintended directions.

Compared with other directive antennae that are used at microwavelengths, the horn developed at the Institute is peculiarly easy to operate since but one adjustment is necessary. The simplicity of construction of the horn, which can be made from sheet copper or galvanized iron, makes it an economical system to build. The fact that no insulators are used contributes to efficient operation.

One feature of the electromagnetic horn of rectangular cross section is that the sharpness of the beam in the two directions at right angles to its length can be controlled by varying the flares of the two sets of opposite sides. In this way, a fan-shaped beam may be sent out that is sharp in one plane and broad in another. By changing the shape of the horn, a cigar-shaped beam can be radiated. The sides of these beams are unusually clean cut and free from irregularities. It is these features that make the horn adaptable to so many uses and give it advantages over older types of antennae.

Waves may be started in the horn by locating a small rod antenna only a few inches long directly in its throat. Waves may also be started by connecting to the horn a hollow pipe carrying the ultrashort radio waves. The first method may be likened to an old-style phonograph, where the diaphragm and needle excited the sound waves directly in the throat of the now antiquated phonograph horn. The second method resembles a speaking tube connected to the small end of a horn.

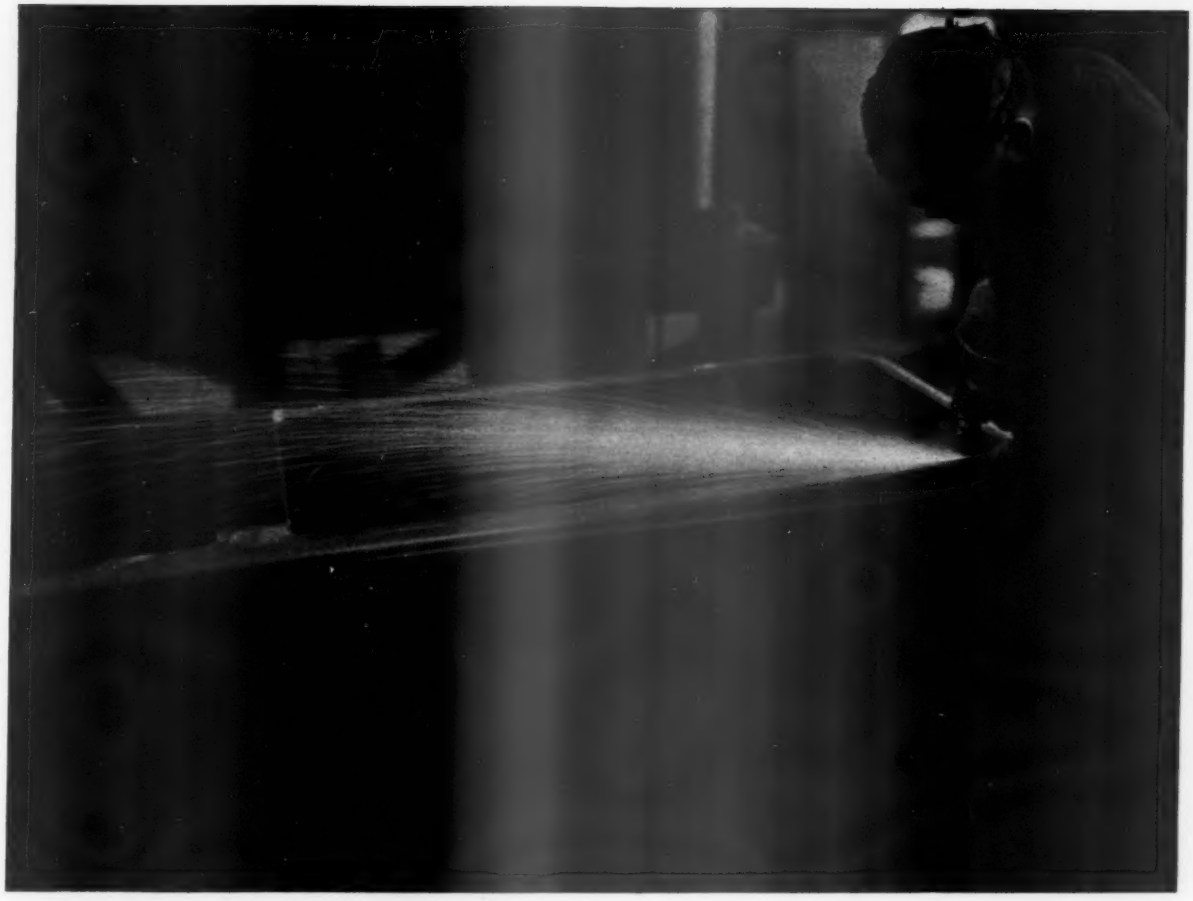
Chemical Engineering at Technology

OUR series of Visiting Committee Reports continues this month with a condensation of the statement made to the Institute's Corporation by the Committee appointed to visit the Department of Chemical Engineering during the current academic year.

CHEMICAL ENGINEERING *

IN 1936 the Visiting Committee for the Department emphasized the Department's need for three more senior staff members and for more and better space for

* Members of this Committee for 1937–1938 are: Bradley Dewey, '09, Chairman, Arthur C. Dorrance, '14, Thomas Midgley, Jr., Samuel Cabot, '09, Frank W. Lovejoy, '94, Charles M. A. Stine, and Robert E. Wilson, '16.



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the staff. At its meeting on February 18 of this year, the Committee found that since that time the senior staff has been strengthened by the appointment of one assistant professor, who is now to be promoted to an associate professorship. One and possibly two more assistant professors will be nominated this summer. More space has been allocated to the staff. Though many of the senior staff are located in the basement, the arrangement of offices and their proximity to the research students is much better than at the time of the last meeting. This situation may serve for the present, but it is far from ideal for a staff of the size and quality of that in this important Department.

The enrollment in chemical engineering is now approximately 13½ per cent of the undergraduate student body of the Institute and 18½ per cent of the graduate group. Over 40 per cent of the graduate group are candidates for the doctor of science degree. The 118 graduate students include men from 65 different colleges. The enrollment of sophomores in the Course was cut at midyears of this year from 96 to 65, and it is felt that this step will help to improve the quality of the undergraduate training. The staff members are giving new courses in chemical engineering to students of other Courses.

In a new move to stimulate research productivity, six research assistants have been appointed this year. These men receive a small stipend and are engaged on doctors' theses which will require approximately 50 per cent more than the usual time. In consequence they are expected to turn out considerably more than the normal contribution which would justify the awarding of the doctor's degree, and to assist and stimulate the thesis research of men working for the masters' and bachelors' degrees.

With the foregoing background, the Committee discussed at length probable future trends and requirements of the Department. The following synopsis covers the points which it is thought should be of greatest help to the administration. There is no reason to fear that the Chemical Engineering Department of the Institute is about to lose its recognized leadership in the fields in which it has pioneered with the basic unit operations now commonly associated with chemical engineering.

However, the very thoroughness with which the Department has developed these unit operations (for example, distillation, heat transfer, and absorption) leads some to wonder whether the present staff and facilities are sufficient to permit the same type of pioneering in the new fields for which chemical engineers will be in ever increasing demand. The Committee also realizes (as does the Head of the Course) that the chemical engineer could profitably employ more knowledge of related subjects such as organic and physical chemistry, business, mechanical engineering, and metallurgy. Time limitations unfortunately prevent the inclusion of all the desirable work in the standard curriculum. It is felt that though it may not be necessary to do anything at this time about either of these points, they should be periodically reviewed, and students with bents toward particular subjects should be encouraged to follow them when selecting electives.

The Committee feels that the Department should actively encourage research in fields involving the application of chemical engineering to (1) processes incident to organic chemical reactions (e.g., nitration, sulphonation, polymerization) and those involving colloidal phenomena (the action of wetting and dispersing agents, detergents, softeners, plasticizers, and so on) and (2) some of the undeveloped unit operations, such as heat transfer in the low-temperature field, crushing and grinding, separation, classification, and mixing.

M.I.T. should bring to bear upon these fields new tools and methods of attack. The chemical engineers of the future must be equipped to solve the problems incident to developing continuous processes for now discontinuous chains of reactions of the new synthetic organic chemistry of today and tomorrow. The Committee feels that some of the Department's staff members should be encouraged to specialize in one or more of these fields and should be helped, as well as urged, to strengthen their contacts with, and knowledge of, industries that would broaden their appreciation of the problems in these fields.

The Committee feels that probable future interests in these fields should weigh heavily in the choosing of candidates for new senior staff positions, and the Department budget should include an appropriation to be spent, under the direction of the Department Head, to facilitate the making of contacts with, and the study of, such fields by the staff.

To summarize, the Committee feels that the program of the Department in the future must emphasize progress in all four of the following fields: (a) further development of the special unit operations that have been studied in the past; (b) similar unit operations that have been studied but little in the past; (c) processes involving the principal reactions of organic chemistry; (d) processes involving colloidal phenomena.

Without detracting from the foregoing major recommendations, the Committee wishes to approve continuing support of the Department's program of financial aid (independent of financial need) to research assistants in return for (1) more time and a better thesis and (2) some supervision of the thesis work of candidates for bachelors' and masters' degrees.

In closing, the Committee again emphasizes that its fears for the future are the result of the growth which has accompanied the Department's success in the past. It feels that the enthusiasm and genius which have resulted in present progress are ever growing, but that the problems to be tackled and solved are growing faster than the personnel available. It is this growth which makes the administrative problem a difficult one and which makes the Committee feel its responsibility to point out the considerations which should be weighed in spending the all too limited available funds.

Amber, the Arctic, and Cosmic Rays

IN New Zealand, in Peru and Mexico, in three stations in the United States, and at sea in the Pacific, cosmic-ray intensity meters have been in operation for some time in a world-wide investigation of cosmic radiation, which is being carried (*Continued on page 387*)

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Should I Trade In My Car?

A Method for Determining the Economic Time

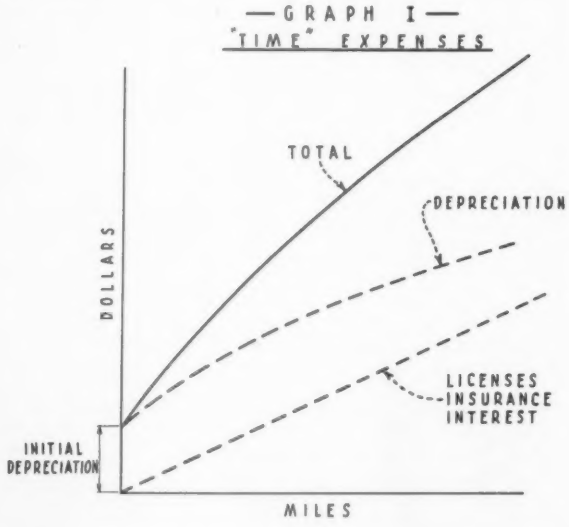
By Vernon G. Lippitt

TRADING in your used car at the proper time will save you money. But how, you ask, can you determine the proper time? I have devised a method which, I think, will enable the car owner to determine the economic trade-in time, provided he has complete expense data. I assume, of course, that the owner can purchase a new car at the economically best time and that he is willing to disregard esthetic considerations, and I neglect the possibility of the sudden termination of the old car's life by breakdown or accident.

By the economic time to turn in your used car I mean the time at which the car should be turned in so that the cost per mile of your automobile transportation services during the life of this car and that of your next car shall be a minimum. I take the mileage traveled to be a measure of the transportation service given by the car and wish to find when the car should be traded in so that the cost of this service shall be a minimum not over the life of this car alone but over the combined lifetime of this and the next car, which is probably as far ahead as one can look. The essential factors in this determination are the foregoing ones. The depreciation cost is high when the car is new, and the operating, repair, and replacement costs rise as the car grows older. We want to find a point which strikes an economic balance between these two factors and which will give a minimum resultant cost per mile.

First of all, of course, we must have the expense data for the car in order to solve the problem. If your antipathy toward keeping an account of your car expense is greater than your desire to save money by turning in your car at the proper time, you will probably not bother with this problem. However, assuming that you are interested and assuming that we have the complete expense data to the present, we next need to select a method of treating the data to find the desired solution to the problem. My general method is to divide the expense items into two main groups: first, expenses dependent primarily on time, or age of the car; and second, operating expenses dependent primarily on mileage traveled. I shall determine these expenses independently and then combine them to obtain a graph of total car expense as a function of mileage traveled. And from this graph and calculations based on it, I shall deterine the economic time to turn in the car.

Time expenses include driver's and car licenses, insurance, interest expenses, and depreciation. Let us first consider the items of licenses, insurance, and interest. Payments for these items are made in lump sums but should logically be charged equally to each week or month of the car's life. We can spread these expenses evenly by totaling the yearly expense for these items and finding the average cost per month. At the end of each month we can sum up these items of expense and plot the sum against the mileage indicated by the speedometer at the end of the month. If you travel equal distances each month, the graph of these items of time expense will be a straight line from the origin upward at a slope proportional to the monthly average (Graph I).



The remaining item in the time expenses is depreciation. By depreciation expense I mean the difference between the purchase price of the car and the cash allowance you would get for the car on a trade-in. The cost of the car — initial and installment payments — does not appear in this analysis; the depreciation cost takes care of the amount you pay for possession of the car. Now the depreciation is not strictly dependent on time alone — it depends somewhat on the mileage traveled, the care given the car, and the model of new car you are going to get — but it comes closer to being dependent on time than on mileage, I think. So I have included it in the time costs. The amount of depreciation expense up to any time may be determined by taking the car to a dealer from time to time for estimates of trade-in value, or it may be predetermined by asking the dealer what is the depreciation schedule on the car. At any rate, when determined the depreciation expense may also be plotted as a function of the miles traveled since purchase. There will probably be some depreciation immediately upon purchase; so this curve will not start at zero dollars. The curves for the items of time expense may then be added to find the resultant variation of time expenses with mileage traveled (Graph I, again).

Now let us examine the operating, or mileage, expenses. These include gas and oil, garage servicing and repair, tires and other replacements, and miscellaneous expenses — in fact all car expenses not included under

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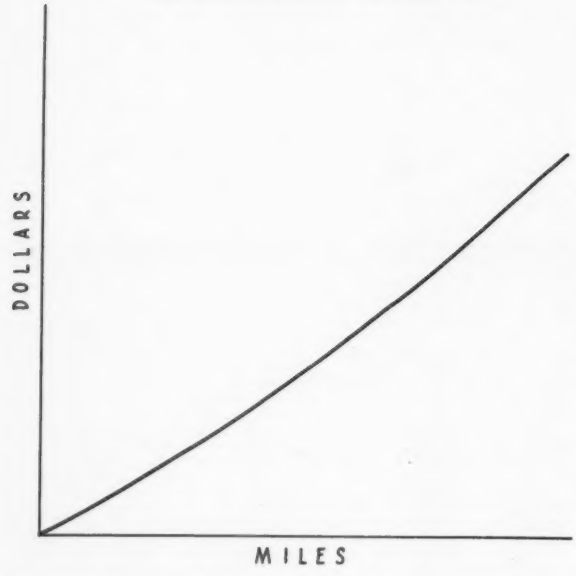
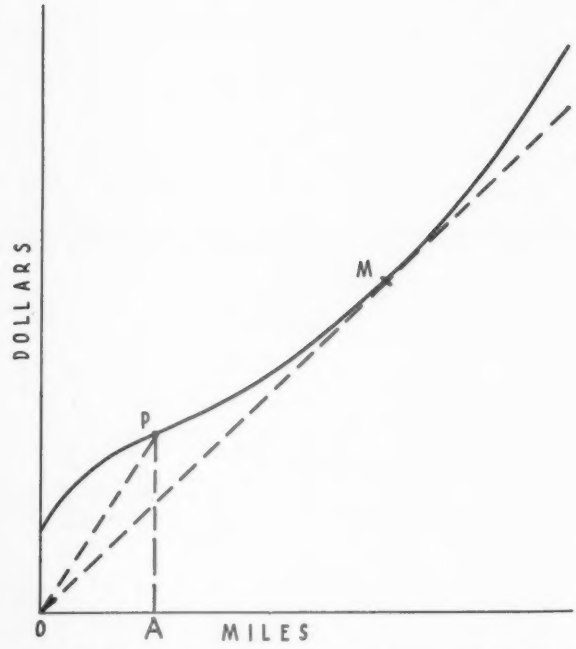
—GRAPH II—
"MILEAGE" EXPENSES



—GRAPH III—
TOTAL CAR EXPENSES

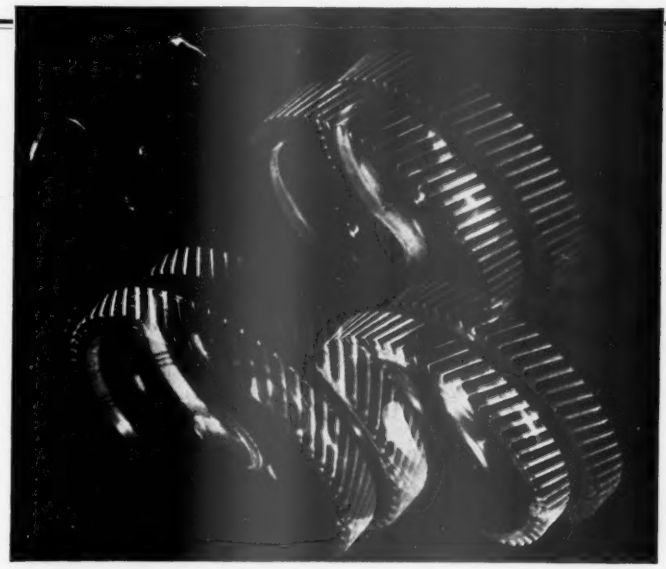


time expenses. These items may best be handled, I think, by simply adding them together, say at the end of each month, and plotting the total mileage expenses to date against the speedometer reading at the end of the month. Unlike the curve of time expenses, this graph cannot well be predicted much in advance but must be plotted as the actual expense data are obtained. This graph will have somewhat the shape illustrated in Graph II, rising at an increasing rate with distance traveled.

Adding the mileage costs and the time costs at all points, we obtain a graph of total car expense as a function of miles traveled since purchase (Graph III).

We know that the cost per mile of our transportation services up to any point in the life of the car is given by total expenses divided by total miles. Thus at point P the cost per mile is AP cents divided by OA miles. But AP/OA is a measure of the steepness of the slope of the line OP. So, in general, the average cost per mile up to any point P in the car's life is proportional to the slope of the line OP on a graph with axes as shown, and to find the point at which the cost per mile is a minimum we have merely to determine the point on the expense curve for which the slope of such a line is minimum. On Graph III point M is obviously the point of minimum cost per mile.

However, point M is not necessarily the point at which to turn in the car. The fundamental criterion is that the car should be turned in at the point which makes the cost per mile of transportation service a minimum over the combined life of this car and the next. If one can estimate the average cost per mile which a new car will give and if it differs from the average cost per mile of the old car, then the optimum trade-in time can be located but will not fall at M. (*Concluded on page 376*)



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SHOULD I TRADE IN MY CAR?

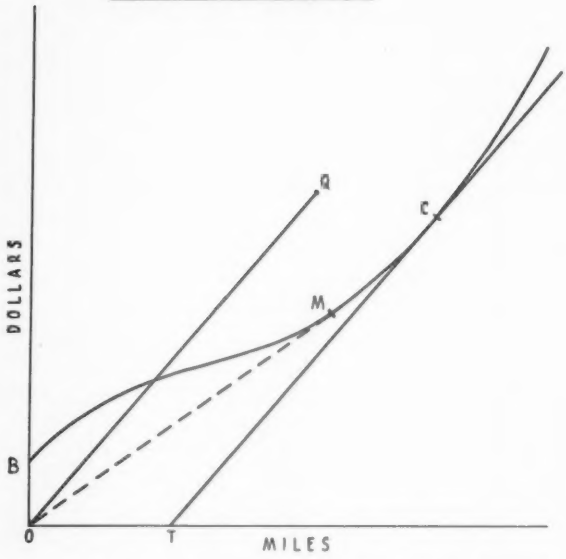
(*Concluded from page 374*)

Suppose you estimate that the new car will give a minimum cost of four cents per mile. And suppose you are now at point *M* on the curve for the old car, for which the average equals three cents per mile. Let us assume that you keep the old car a month past the point *M*. During this month the old car might average three and one half cents per mile. Then it was economical to use the old car for that month rather than to buy a new car and get your transportation at four cents per mile. Let's then assume you keep the old car a while longer. At some later time the old car might average four and one half cents per mile over a monthly period. Then it would have been cheaper to buy the new car at the beginning of the month so that you could have obtained the month's transportation at four cents per mile rather than the four and one half cents per mile of the old car. In general, if the estimated minimum cost per mile for the new car differs from that for the old car, the economic trade-in time is that at which the cost per mile for the old car over a short period of time rises just to equal the minimum cost per mile for the new car.

Suppose that you had an expense curve like *BMC* (Graph IV), and suppose that a new car would give you a line *OQ* whose slope represents its minimum cost per mile, higher than the cost per mile at point *M* for the old car. The proper time at which to trade in the old car is at point *C*. The tangent to the expense curve for the old car is here parallel to the line *OQ*. Or, in other words, the cost per mile for the old car over a small period of time (represented by the slope of tangent *CT*) is just equal to the minimum cost per mile obtainable from the new car (represented by the slope of line *OQ*). And this is our general criterion for determining the economic time to turn in a used car.

—GRAPH IV—

TOTAL CAR EXPENSES



Of course, many practical conditions arise which might vary the economic time — a serious accident, a long trip, and so on — and the expense curves will be irregular instead of smoothly curved as I have shown here. But by using this general method and applying the fundamental criterion of minimum cost per mile over the life of this car and the next, I believe one can determine easily and intelligently the economic time at which an old car should be turned in on a new model.

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EXPLORING THE BODY WITH ATOMS

(*Continued from page 355*)

By changing the time of wait, we can also watch the replacement of the labeled phosphorus by new (and unlabeled) phosphorus and therefore obtain a complete picture of the flow of phosphorus into, and eventually out of, the animal's tooth. Some work has already been done on this problem at Copenhagen, and the results indicate that, three days after digestion, some of the labeled phosphorus has collected in the soft, inner part of the teeth and has spread from there clear out to the outer enamel. The importance this work will have on the understanding of tooth growth and decay can be readily imagined.

Work is in progress at Technology on the absorption of iodine by the thyroid gland. The work is being done by Dr. Saul Hertz of the Harvard Medical School and Dr. Arthur Roberts of Professor Robley D. Evans' group here. The results are very satisfactory at present, in spite of the fact that only (*Concluded on page 378*)

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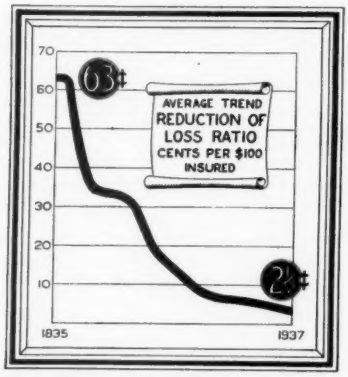

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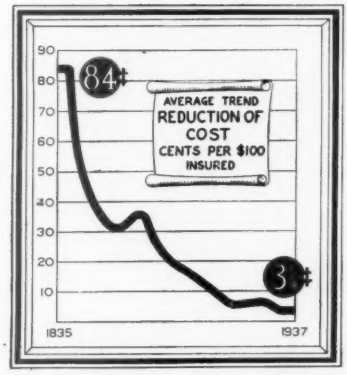

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EXPLORING THE BODY WITH ATOMS

(*Concluded from page 376*)

very weak samples can be made with the generators now available and also despite the fact that the radioactive isotope used has a mean life of only half an hour. The results show that the concentration of iodine by the thyroid is extremely rapid, most of the accumulation occurring within 15 minutes after injection, and that goiterous thyroids accumulate as much as ten times the iodine that normal ones do. By using a newly discovered isotope with a mean life of two weeks and by using the much stronger samples which will be available when the big electrostatic generator is in production, the measurements can be extended considerably. It seems likely that the method will be very useful for the diagnosis and treatment of goiter.

A large number of similar experiments, using different elements and studying the chemical dynamics of other organs, will be carried out here as soon as the production equipment is ready and as fast as financial aid is available. This work, here and elsewhere, should inaugurate a new era in biochemistry.

Another exciting possibility for artificially radioactive substances is to inject them in much larger doses than needed for the studies discussed above — doses large enough to affect cancerous growth, just as radium affects it. The radioactive material can be made chemically harmless (as radium cannot) as, for instance, by using radiosodium in the form of ordinary salt, and it can be injected directly into the growth (there is no use recollecting it, for its radioactivity soon dies out). A more subtle method would be to incorporate the radioactive isotope in a chemical substance which the cancer prefers, destroying the growth because of its own greediness, so to speak — which would be poetic justice indeed. A similar treatment could be used for goiter, employing radioactive iodine. However, these last methods must wait until larger quantities of radioactive isotopes are available.

Technology has a good chance to be in the forefront of this new and immensely useful field of research. The physicists and electrical engineers versed in the production and measurement of radioactive materials are already on the staff and in close coöperation on many of the aspects of the problem. Coöperation with biologists and medical research workers in near-by institutions has also been developed and can be extended when the need arises.

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THE GREAT DETECTIVE STORY

(*Continued from page 359*)

conditions of reflecting horizons at depth. The method is one of correlation. The factors employed are the recognition of the identity of reflections from key beds and the agreement in interval to other reflecting beds of the geologic section.

The usefulness of the refraction seismograph having been greatly exhausted, in 1930 a wave of increased activity developed with the reflection seismograph. The value of the newly perfected method was extremely great. Large companies holding millions of acres in checkerboard leases were enabled to evaluate these and to save many times the cost of exploration by the reduction in rentals. New discoveries were rapidly brought forth, particularly in the Seminole district of Oklahoma, which was peculiarly well adapted to the use of the reflection method. The limitation of the scheme to areas where correlations were possible prevented great activity in the Texas and Louisiana Gulf Coast. This handicap was removed, however, by the discovery of the dip method, wherein the attitude of one or more bedding planes could be measured at discrete locations without attempting continuous delineations thereof as in the correlation method. Improvements in the dip method have led to its widespread use in the discovery and detailing of Gulf Coast structures.

The reflection seismograph accounts for a large part of the present geophysical activity in the United States. In the year 1937 there were, on the average, at least 200 reflection crews at work each month, representing an annual expenditure of more than $25,000,000. These crews were divided between those operated by geophysical contractors and by major oil companies who maintain their own geophysical departments. The general trend of the industry at the present time is for the companies to operate their own department crews. Competition among contractors has led to the development of improved instruments and technique. Among those prominent in the field should be mentioned the principle of the multiple seismometer connection. By employing a group of seismic-wave detectors in a series at a given point, advantage can be taken of the directional selectivity exhibited by such a group. The principle involved is that of the submarine direc- (*Continued on page 382*)

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Reserve for Dividends	270,000	Cash	270,000
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		U. S. Government Bonds (short term)	19,845
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THE GREAT DETECTIVE STORY

(*Continued from page 380*)

tion finder or of the directional selectivity exhibited by multiple shortwave antennae at spaced intervals. The method is covered by a number of patents and is in use throughout the industry. Advances in instrument design have led to the use of 12-channel recording oscillographs, amplifiers of high gain, incorporating automatic volume-control and amplitude-balancing features. Special seismometers have been developed for use in swamp-covered areas of the Gulf Coast and the Gulf of Mexico. Mobility has been a primary consideration in these designs. Special amphibian automotive equipment has also been built to negotiate these marginal areas. At the present time activity is being undertaken in the submerged lands adjacent to the coast, even beyond the three-mile limit. Title to discoveries made in the open water of the Gulf of Mexico is subject to investigation, but this situation apparently does not prevent geophysical activity in this province.

The gradual refinement of method and the increase in details of surveys in coastal areas have led to discovery that production on many domes and structures is affected, if not entirely determined, by faulting. Since the use of the dip method does not permit the direct observation of faults, many of the discoveries made in the Gulf Coast by the reflection seismograph have failed to produce oil. The successful location of a fault by any method may be said to rest upon ability of the geologist to correlate beds across the fault zone. Progress in the solution of this problem was undoubtedly retarded for many years by the prevailing opinion among Gulf Coast geologists that the sediments of this province bore insufficient points of differentiation to permit reliable correlation. The conclusion of the geophysicists in this area was that if geological correlation could not be made, certainly the geophysicist would be foolhardy to undertake it.

In 1929 under a somewhat inauspicious beginning, Conrad Schlumberger introduced into the United States the method of measuring the electrical resistivity of formations *in situ*. Variations in the measured electrical resistivity of the rock, obtained by lowering current and potential electrodes into a well filled with drilling fluid, gave remarkably significant indications of changes in the sediments. Widespread application of the method was prevented by the financial depression of 1930, but continued research developed the interesting point that not only the specific resistivity but also an index to porosity might be obtained by these measurements. The primary value of the method was the establishment of means of correlation among Gulf Coast wells.

The widespread adoption of the Schlumberger method of electrical logging has in many respects altered the general plan of exploration. There is an increasing tendency to drill exploratory or initial wells on a newly discovered prospect by the simplest and cheapest means available. The cost of these wells is greatly reduced by elimination of the need for taking frequent core samples of the formations. Without taking adequate core samples formerly, the driller could pass through formations containing commercial deposits (*Continued on page 384*)

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THE GREAT DETECTIVE STORY

(*Continued from page 382*)

of oil or gas, taking no notice of them. The use of the Schlumberger survey indicates, in most cases without question, the possibility of oil or gas accumulation in any of the formations which have been traversed. In many provinces, therefore, the simple and rapid completion of exploratory holes without the use of coring may become standard practice, depending for final analysis upon the electrical logging method. Other methods of accomplishing this result are in vogue, and competition and technical advance may develop possibilities unthought of at the present time.

The extent to which geophysicists and geologists are pressed to find petroleum in its less obvious locations is indicated by the complexity and ramifications of certain recent developments. In the field of the reflection seismograph, probably the highest degree of instrument complexity is illustrated by the method of Frank Rieber of California. Employing a multiple-recording seismograph, the Rieber method takes a variable-density sound record on 35-millimeter motion picture film. This record is obtained by means of portable field equipment. Upon development, this record is delivered to a photoelectric analyzer at headquarters, wherein the waves recorded by the sound track are transferred by a stylus recording mechanism to a long paper record. This method embodies the principle of composite recording mentioned previously in connection with the series arrangement of seismometers. The compositing agency in this case is optical, and the phase angle at which adjacent traces are combined is controlled by the angle which the optical slit on the sound film makes with the time axis. By compositing the record of all traces at various angles, this method indicates the maximum amplitude when all waves are added in phase. The attitude of the reflecting horizon can be calculated from the records.

Another geophysical means attempting to solve the difficult faulting problems of the Coastal area is exemplified by a patent — familiarly known as the electrical transient method (Eltran) — granted to L. W. Blau. By suddenly applying a current wave to two electrodes placed some distance apart on the surface of the ground, a field is generated within the rock formations. The distribution of this field depends upon the distribution of the conductivity and specific inductive capacity of the formations. If the earth were homogeneous and isotropic, the field would build up to a maximum along an exponential function which might be observed and recorded by two potential electrodes spaced at some distance outside the two current electrodes. Recording of the transient wave thus produced is made on an oscillograph. During the course of the development of these principles, it was found that discontinuities in the recorded wave might be observed under special conditions. Continued study suggested the possibility that these might be caused by abrupt changes in the continuity of earth sediments.

For thousands of years man has noted the occurrence of seeps of petroleum and gas at the surface of the earth. Investigation of many of these local deposits led to the discovery of commercial production. The extent to which this principle may be carried is exemplified by the

present activity in making quantitative analyses of the hydrocarbon gases contained in soil. Many involved theories have been presented, but the general basis of all of them is that the soil gas content should exhibit a maximum in the vicinity of a large subterranean deposit of gas or petroleum. These theories involve the permeability to hydrocarbons of the entire geologic section overlying the deposits. Since most petroliferous sediments are capped with rock layers which effectively seal the deposits within the containing reservoir rock, the degree to which hydrocarbons escape to the surface is problematical. In some instances soil gas content has been found to be a minimum over producing fields. Escape to the surface may be accomplished by the presence of faulted zones or a system of minute vertical fissures in the sediments.

Sometimes core holes are drilled to depths of the order of a thousand feet, and samples of the formations at these depths are analyzed for gas content. These core holes are frequently subjected to electrical logging analysis in an effort to determine the presence of faults. Once the direction of throw in the fault is established by any method, the probable effect upon the distribution of production can be ascertained.

For similar purpose the use of field measurements of electrical resistivity and the potential distribution by direct current and alternating current methods offer immediate possibilities. Some activity is being undertaken along these lines. The cost of field exploration by the electrical method has been greatly reduced during the past year by the Jakosky invention of the mobile electrode. Making contact with the surface of the earth by means of a steel wheel which is attached to a motor truck, this method permits continuous recording of electrical measurements while the truck is in motion. Jakosky also reports depth penetrations to 5,500 feet, a notable advance.

Reconnaissance magnetic surveys are being continued in many areas of the Midcontinent and Mississippi Embayment province. Depending for their observations upon anomalous distribution of the earth's magnetic field, they give indications of structural features in the basement complex. Likewise they indicate the presence of igneous intrusions, many of which may have produced anticlinal structures in overlying and overlapping sediments. The presence of serpentine dykes and plugs in Southwest Texas and other areas indicates the use of the magnetometer for investigation. The existence of many faults in the Balcones zone was strikingly demonstrated through the use of this instrument. The cost of a reconnaissance survey by this method is probably as low as by any adequate geophysical procedure. Depending upon the density of distribution of the points of observation, William M. Barret reports that the cost figure may run from one-half cent to two cents per acre on a reconnaissance basis. Other geophysical methods may run as high as 25 cents an acre where detailed investigation is required.

In any given province the program of exploration is largely one of elimination. The chief geologist or other official in charge will map out an area which for some reasons indicates to him the possibility of oil accumulation. He first undertakes to (*Continued on page 386*)

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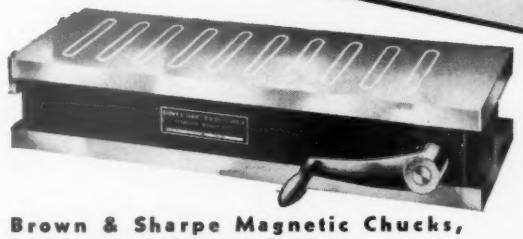

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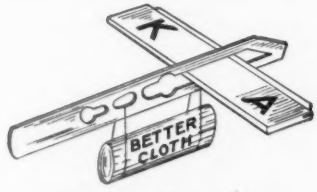

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THE GREAT DETECTIVE STORY

(*Continued from page 385*)

map the surface geology, either by field parties or by aerial photography. He will have examined and interpreted all available subsurface data for clues for possible traps. At this point it might be logical to explore the geological situation further by means of core drilling. Should any of these investigations lead to favorable conclusions, some low-cost reconnaissance method of geophysical investigation might be employed, for instance the gravity method or the magnetic method. Should all indications continue favorable, the next logical step would be surveying by the reflection seismograph to obtain detailed structure data.

Upon completion of such a survey, any area which had shown consistently favorable indications would be ready for leasing. The land department of the exploring oil company, upon receipt of the proper advice, would proceed to purchase at current prices all of the available leases in the area. Of course that the entire favorable area be brought under the control of the exploring company would be highly desirable, but in the event that competition prevailed, the discoverer of the potential field would take whatever was available at a reasonable price. As development of the project advanced, favorable trading with other lease holders in the area might be carried out. Finally after all known means of exploration have been employed, the final test is the drilling of a well. Although all of the exploratory means may indicate favorable conditions, none of them has ever been able to perform directly upon the actual deposit of petroleum. The science of petroleum exploration may be said to be an evaluation of the probabilities of the occurrence of oil or gas. If the cost of acquiring acreage and drilling a well is not out of proportion to the prize at stake, the chances are that even hazy indications of an oil field will be investigated to the end.

A canvass of most of the operators of geophysical methods throughout the United States for 1937 reveals the following approximate activities: Reflection seismograph, 2,400 crew months; torsion balance, at least 420 crew months; gravimeter, 360 crew months; magnetometer, 650; electrical, aside from well-logging methods, 120; Eltran, 60 crew months. Reports for all the activities except for the reflection seismograph are confined to the southern, southwestern, and western portions of the United States. Data for other areas were not available. An estimate of the number of crews making electrical logging analyses would reach a figure of at least 25 parties.

Such is the story of how oil is found. What now of the future? Can we say that the methods as they exist today are adequate for the needs of the nation? Much speculation has been expended upon this question, and it is doubtful if a definite answer can be had. As in the case of finding a pool of oil, the answer is at best an evaluation of probabilities. Periodically, outstanding experts in discovery make predictions regarding the future reserves of the nation. Invariably these estimates have had to be revised, but the following figures prepared in 1937 by the Department of Public Relations, American Petroleum Institute, in terms of estimated reserves are of interest: 1914 (Arnold), 6,000,000,000 barrels; 1915 (United States Geological Survey), 7,500,000,000; 1921 (American Association of Petroleum Geologists — United States Geological Survey), 9,000,000,000; 1925 (American Petroleum Institute), 5,000,000,000; 1937 (American Petroleum Institute), 13,063,000,000 barrels.

There are two methods by which an estimate of the future discovery rate might be attained. The first of these was suggested by Wallace E. Pratt in his paper presented at the annual meeting of the American Association of Petroleum Geologists in Los Angeles, Calif., in March, 1937. Mr. Pratt showed from his studies that the rate of discovery based on the number of barrels discovered annually, or upon the number of pools whose ultimate reserves were estimated at more than 20,000,000 barrels each, rose gradually from 1901 to a maximum in the five-year period 1926 to 1930, and then declined at approximately the same rate. In both instances this analysis showed that the fruitfulness of exploration efforts is not so great at the present time as it was 10 years ago. On the other hand the results of these studies showed that geophysical methods in the period 1931 to 1935 accounted for 55 per cent of all discoveries. It might be said that the utility of these methods is still on the increase and that the law of diminishing returns has not yet begun to work seriously. Gratifying it is to know that during this same period 85 per cent of the discoveries were based upon scientific programs, whereas purely random drilling accounts for but 12 per cent of the total discoveries. At the beginning of this century random drilling accounted for 30 per cent of the whole. With the exception of the great East Texas field, the amount of petroleum discovered by purely random drilling has continued to be a lesser portion of the discoveries of each succeeding year.

Another effort to evaluate future possibilities of the industry was made by Dr. Alexander Deussen, consulting petroleum geologist, at the March meeting of the American Association of Petroleum Geologists. Dr. Deussen outlined a method which is analogous to that of sampling employed in industry. Considering for his studies the prolific area of the Texas and Louisiana Gulf Coast, he gave figures showing that this area had produced more than 35 per cent of the proved reserves of the United States. Because of the high rate of success in this province, probably more detailed exploration work has been completed here than in any other province of the United States. Taking as his yardstick Harris County, Texas, Dr. Deussen calculated that this county had the greatest density of exploration and drilling of the entire Gulf Coast province. Assuming that because of the intensive work, all of the potential discoveries have been made in Harris County, Dr. Deussen's calculations showed that this average density of the distribution of producing fields, when applied to the remainder of the Gulf Coast province, would bring the number of new fields to be discovered to the astounding total of 351. This estimate is based upon the fact that in Harris County the area of the producing fields to that of the entire county is 1.6 per cent. Upon this basis the total number of fields, even at one per cent of the Gulf Coast province, should equal 516. At the present time

there are 165 producing fields in this province. The probable total recovery of these additional 351 oil fields amounts to nearly 10,000,000,000 barrels!

Although there may be tremendous oil reserves yet to be discovered, it is generally agreed that the technique of oil finding must be improved in the near future. The decline in discovery rate during the past five years demonstrates that even the best of the newly established scientific methods have failed to maintain the discovery rate of older methods. Recourse cannot be had to the older methods because they have long since entered the phase of diminishing returns. There is abundant evidence that adequate petroleum reserves can be maintained during the present generation. The cost of petroleum in the future, however, will be largely determined by the success of the exploration scientists in improving the efficiency and power of existing exploration techniques and in discovering new techniques.

THE INSTITUTE GAZETTE

(*Continued from page 370*)

on under the auspices of the Carnegie Institution of Washington. The meters, in the design and construction of which Professor Ralph D. Bennett of the Institute's Department of Electrical Engineering was associated with Dr. Arthur H. Compton and Dr. A. W. Simon of the University of Chicago, are an interesting combination of ruggedness and delicacy. For example, massive steel spheres and a one and a half ton shield of lead are employed in them to house argon gas, which, at a pressure of 750 pounds to the square inch, responds to the penetration of the rays in a measurable electrical way. At the same time, thin films of wax have been used to seal openings and tubes connecting the gas-inclosed mechanism with the registering and recording system—a clock-driven strip of photographic film in a camera, which records the measurements over a period of months.

Extremes of temperature, with consequent variations in pressure and different degrees of expansion or contraction in the steel, brass, wax, and other materials used in the meters, may result in leakage of the argon—an expensive loss, as well as a hindrance to efficient operation of the meters. Professor Bennett has lately been engaged in forestalling such dangers by the perfection of an amber-neoprene gasket which has proved successful in tests during which the meter was chilled to 95 degrees below zero F. by the use of carbon dioxide snow. In developing the new seal, Professor Bennett determined the coefficient of expansion of amber as 24 parts in a million for each degree of temperature. For brass, the figure is 10 parts per million, and for steel, six.

This kind of insurance against difficulties was made more necessary by the next steps planned in the radiation study. A meter will be transported this summer to the Danish meteorological station at Godhavn in Greenland, well within the Arctic Circle. In operation, it will be housed in the station, of course, but during the journey or as the result of accident, it may be subjected to thermal dangers which the amber gasket is expected to avert. Another (*Continued on page 388*)

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THE INSTITUTE GAZETTE

(Continued from page 387)

meter will be journeying back and forth between Seattle, Wash., and Juneau, Alaska, on one of the vessels of the Alaska Transportation Company, making a round trip each week for four months and two trips a month for the rest of the year.

The seagoing meter in its Alaskan voyaging will be extending surveys made last year, in which a meter traveled between Vancouver, British Columbia, and Sydney, Australia, on the S.S. *Aorangi*. The arctic meter at Godhavn will serve to push farther north the series of land meters already mentioned, which are distributed in a band roughly between the 80th and 100th meridians, at Huancayo, Peru; Mexico City, Mexico; Cheltenham, Md.; Chicago, Ill.; and at the Institute in Cambridge. There is, in addition, a meter stationed in the Eastern Hemisphere at Christchurch, New Zealand. The records being collected by these meters and by their nautical compeers yield data on the variation of cosmic-ray intensity with latitude and with time. Since the rays are affected by the earth's magnetic field, the study is concerned with geomagnetic rather than with the familiar geographical latitude of everyday maps. The difference between these two kinds of measurement of the earth's surface — a difference resulting from the fact that the magnetic north and south poles are some 20 degrees removed from the true geographic pole — may be visualized by thinking of a conventional globe tightly wrapped in a fish net so that the cords of the net lie on the meridians and parallels of geographic longitude and latitude. If the fish net is gathered in knots that lie at the geographic north and south poles, and the knots are pulled away from the poles an inch or two, depending on the size of the globe used, the cords of latitude will fall upon the geomagnetic divisions. Completion of the chain of meters by the Greenland installation this summer will extend the range of observation from 52 degrees south to 80 degrees north geomagnetic latitude.

Where Is North?

INVESTIGATORS in Technology's Department of Aeronautical Engineering have for some years been studying the instruments used in air navigation. Their

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purpose is to replace vague ideas about the instruments by exact knowledge and to secure quantitative estimates of how to improve the usefulness of their tools by cutting down errors in performance due to the rapidly changing conditions encountered during flight. The magnetic compass and the meter which indicates the rate at which a plane is climbing have most recently been studied for these purposes.

The method followed by the investigators — Professor Charles S. Draper, '26, William H. Cook, Jr., '35, and George V. Schliestett, '36, of the Institute and Walter McKay of Sperry Products, Inc. — has been to predict theoretically the performance to be expected from the instrument during various specific maneuvers and then to check the prediction by flight tests. During these, the plane is put through the specified paces, while a moving-picture camera watches the instruments in question, which are specially mounted for ease in observation. Data collected by the film during flight are then used to check theory. By this means it is possible to systematize knowledge concerning the operation of the instruments and to make that knowledge precise. The factors of flight which control the error of the instruments are thus indicated, with results that may well expedite future design looking to a minimization of the errors.

In studying the magnetic compass, Professor Draper and Messrs. Cook and McKay were concerned with what is known as the northerly turning error. The turning error occurs when, as the course of the plane is changed, the compass card oscillates erratically and does not accurately indicate the relation of the course to the magnetic pole. It is most pronounced when the plane turns out of a northerly course; hence the name "northerly turning error." It is in turns, of course, that the compass is most needed; in these turns out of a northerly course, the compass in the initial instants indicates a turn in the wrong direction. In turns out of a southerly course, the compass in the first moments indicates the direction properly but greatly exaggerates the angle turned by the airplane. Analyzing the errors and studying the effects of the damping, or slowing of the motion, of the compass card by the liquid in which it is immersed, the investigators have found that deviation may be cut down by reducing the controlling force — the action between the magnets of the card and the earth's field — and increasing the mass of the moving element — the card. Further problems concerning the compass are under study.

The rate-of-climb meter is very important in blind flying as an aid to level flight and is likewise important in checking the ascent or descent of a plane with respect to steadiness and rate. The rate of change in atmospheric pressure as the plane climbs or descends is measured by means of a pressure gauge and capillary leak. It has always been vaguely known that the instrument would give an inexact reading in rapid maneuvers because the registering operation lags slightly behind the changes in pressure, so that in both phase and amplitude, error occurs. Having analyzed the error and set up a hypothesis, Professor (*Concluded on page 390*)

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THE INSTITUTE GAZETTE

(*Concluded from page 389*)

Draper and Mr. Schliestett checked it by photography during test flights and found their theory entirely confirmed by observation. As was true with the compass, the factors controlling the error in the rate-of-climb meter are indicated by coefficients determined in the tests. Sudden application of force on the elevators of an airplane trying to hold a level course causes responses in very great error, so great that the instrument may indicate a climb when the airplane in reality is losing altitude. The error of the instrument, moreover, is found to increase with increasing rate of change of altitude. For an accurate reading with modern meters, conditions must be maintained constant for a period between six and 12 seconds.

From this study, ability to predict the behavior of the meter during flight is secured; improvement in design may be assisted as a result, although the error is probably permanent.

Air Conditioning

TO illustrate and study the fundamental principles of air conditioning, to ascertain the efficiency and capacity of various types of air-conditioning equipment, and to study their operation and control are the purposes of the Institute's air-conditioning laboratory, which is now in the process of establishment in new quarters under the direction of Professor James Holt, '19, of the Department of Mechanical Engineering.

Various types of air-conditioning equipment are installed for operation in the laboratory, which occupies two rooms, one of which — the laboratory proper — can be air conditioned by means of apparatus in the works room adjoining. One problem now under attack is the determination of moisture flow through a wall or around a window — a study of importance in connection with summer air-conditioning programs — which leads to passage of moisture through walls and window cracks because of differing vapor pressures. Two model chambers are being used in this study, the air in one being humidified, that in the other dehumidified. Quantitative measurements of the leakage into the dehumidified chamber are being secured with a view to establishing theoretical checks for empirical results. Undergraduate teaching is aided also by these results.

Coöperative work with the Department of Biology and Public Health, following the coöperative practice characteristic of all Technology research, has engaged the use of the air-conditioning laboratory in an interesting investigation of the effect of humidity, temperature, and air motion on the preservation of food in domestic refrigerators. For this work, a room resembling a butcher's refrigerator has been held at a temperature of 35 or 40 degrees F. Food cases in the room were kept at different humidities, and three different air motions were tested at each humidity. Surprising differences in the period of preservation of food in the various cases were noted.

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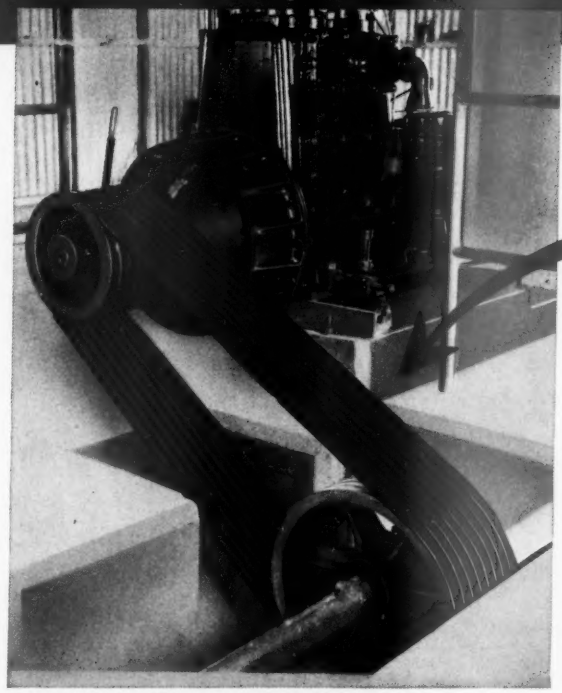

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